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VOL. XIV, NO. 1 JANUARY, 1932 Old Series Vol. XXX, NO. 1

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THE MECHANICS OF MUSCULAR CONTRACTURES IN WRIST AND FINGERS*

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The objective of this study is to show that muscular contractures are subordinated to biophysical laws. The selection of wrist and finger contractures to demonstrate the operation of these laws is a mere matter of expediency. It is not to be inferred that, in contractures, the other structures of the locomotor system—the bones, joints, and ligaments—are not similarly dependent upon physical factors. But, in muscular contracture or contracture in the stricter sense, we can define and formulate certain dynamic and static influences operative in producing the pathological situation. It is this biophysical analysis which makes for a better grasp of the inherent nature of contracture.

In order to make a discussion of this kind worth while two things must be shown: first, that our clinical conception of muscular contractures is inadequate for the understanding of its nature; and, second, that the mechanical analysis adds something definite which is not only of theoretical interest, but also of practical use. First of all, contracture is not a haphazard event; it has regularity and consistency which indicates that it follows physical laws. If it is possible to ascertain, by measurement and trial, the physical properties of the muscles under normal and pathological conditions, one should be able to substitute the definite values obtained in the general formula by which the laws find their mathematical expression. Unfortunately, the physiological fluctuations make it next to impossible to set up the same standard numerical values of such factors as elasticity, viscosity, and contractile power, as one can obtain from inert homogenous material. On the other hand, we are not so much concerned with absolute values as we are with establishing relations between the physical properties of the muscles in specific situations and their visible locomotor effect.

*Presented at the Annual Meeting of the American Orthopaedic Association, Memphis, Tennessee, April 16, 1931.

Looking at the mechanical complex of contracture as a whole, we may expect to obtain three types of data from clinical and experimental observations: first, there is the mechanical situation in a stricter sense, which comprises the anatomic arrangement and the external influences under which the muscles work; secondly, there is the innervational factor which determines the states of tension and relaxation of the muscle; and, third, there are the intrinsic physical properties of the muscle tissue itself. Physiologists interested in locomotion have studied the physiological aspect of the problem from all three points of view; on the pathological side, however, our knowledge is still meager and inadequate.

The relationship of all three types of physical factors and the development of myogenetic contractures can be cited as follows:

1. Myogenetic contractures may be the result of a pure muscle imbalance on the basis of a defect or loss of part of the muscular apparatus surrounding the articulation. This implies a redistribution of the muscle power and a new pathological equilibrium. To this, the remaining muscle material becomes adapted by a gradual change in its anatomical make-up. The normal, neutral state of balance obtaining under physiological conditions must yield to a new, pathological one. It is in this group that the external factors leading to contractures may be studied most advantageously, since all primary intrinsic muscle changes are absent. Infantile, obstetrical, and peripheral paralysis belong to this group.

2. A redistribution of the normal muscle power is created, not because of defect or loss of certain portions, but by virtue of the uneven distribution of the innervational impulses. This group is represented by spastic paralysis. The fact that weakness or paresis of certain muscle groups may coexist does not make any essential difference because the first and foremost factor is a loss of cerebral inhibition of subcortical and reflex stimuli.

This group is more difficult to analyze because it is impossible to ascertain quantitative values of innervational impulses and because of the utmost instability of the pathological equilibrium.

3. In the third group, the pathological histomechanics play the deciding part. They entail changes in the intrinsic properties of the muscle,—changes in elasticity, ductility, and viscosity. Pathologically, these are characterized by the degenerative and myositic processes, followed by shrinkage and induration. From the mechanical point of view, the analysis of this type of contracture is still more difficult because we are unable to evaluate in exact terms the changes of intrinsic properties of the muscle tissue, except by loose comparison with the values known for the normal muscle.

We have, then, three types of data to consider: the extrinsic mechanical, the innervational, and the histomechanical.

I. THE PARALYTIC CONTRACTURES

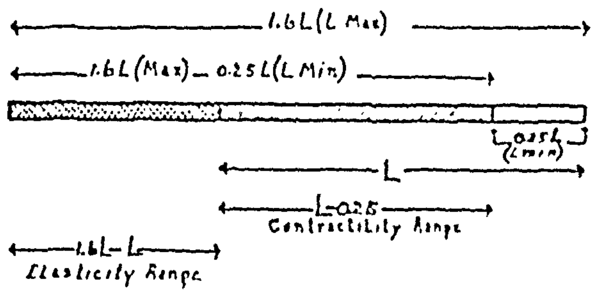
The increasing elastic tension of the antagonist and the decreasing elastic tension of the contracting agonist determine the neutral point of equilibrium.

Let us first consider the simplest situation,—the paralysis of the extensors of the wrist. Normally, the neutral position is twelve degrees' dorsiflexion and three degrees' ulnar abduction. In this position, all requirements for balance are met: all rotation moments of ulnar and radial abduction, as well as of flexion and extension of the wrist, sum up to zero.

What factors determine the new equilibrium?

Passively, there is the elastic tension of the paralyzed extensors of the wrist. A glance at the so called length tension field of the non-innervated muscle teaches us that the resistance of a muscle to passive stretching under a load increases rapidly, and the rate of increase is given by a hyperbolic curve. This is in contrast to the innervated muscle in which resistance to tension increases in arithmetical proportion to the load. This point is of importance for the pathological position because we must expect comparatively early check of contracture.

Another factor is the shortening ability of the active muscle. Physiology teaches us that, with increasing contraction, tension in the muscle decreases rapidly. Therefore, for this reason also, a neutral level must be found, in a position not too extreme, where the increasing elasticity resistance of the extensors and the decreasing tension of the contracting flexors neutralize each other. In time, the flexor muscle will adapt itself to its new position by becoming structurally shortened. It is no longer able to control more than the contraction range, even if the contracture were released. Through its new excursion range it can sweep with perfect ease and normal display of strength, but it cannot go beyond this range because of the adaptive shortening of the muscle fibers. In the normal, the maximum length of the distended fiber is one and six-tenths times and the minimum length of the contracted fiber is twenty-five-hundredths times the natural (resting) length of the muscle. The range between these extremes is one and thirty-five-hundredths times the natural length. Within this range, all motor events occur. The ratio between this difference of extremes to the natural length is the index for the amount of excursion which the muscle can cover. The greater this difference (L max. $-$ L min.) in respect to the muscle length (L), the greater the amplitude. Conversely, the greater the length of the resting fiber (L) compared with the difference between the extremes $\dfrac{L}{L\ max. - L\ min.}$, the greater is the power which it can display in the terminal positions. This reciprocal $\dfrac{L}{L\ max. - L\ min.}$ is, therefore, the index for efficiency. In contracture the difference between extremes is smaller, since the muscle can contract or stretch but little; consequently, the remaining amplitude is small. Conversely, because of the smallness of amplitude, the efficiency $\dfrac{L}{La - Li}$ within its narrow range is comparatively greater. So we find the muscle fully adapted to the new situation; the process of adaptation is even carried to the point of conforming the joint



1) L = natural length
2) 1.6 L - L = elasticity range
3) 1.6 L maximum lengthening
4) 1.6 L - 0.25 L maxi-minimum difference
5) 0.25 L maximum shortening
6) L - 0.25 contractility range

7) EXCURSION INDEX (AMPLITUDE) $\frac{L\ max - L\ min}{L}$

8) EFFICIENCY INDEX (ACTIVE SUFFICIENCY) $\frac{L}{L\ max - L\ min}$

FIG. 1

Relation of natural length, contractility range, and elasticity range to excursion and efficiency index.

constituents to the new mechanical arrangement. In this way a new and harmonic mechanical unit, complete and rational in itself, is created. Any discrepancy between too short a casual muscle length and too great an amplitude of motion makes the muscle actively insufficient. It can no longer display power or tension in positions beyond those for which it is fitted by virtue of its natural or assumed length (Fig. 1).

The flexor muscles of the wrist are comparatively short-fibered muscles. Their total shortening varies from three and five-tenths centimeters for the flexor carpi radialis to four and four-tenths centimeters for the flexor carpi ulnaris. On the other hand, their rotation moment in respect to the wrist joint is great. The rotation moment for flexor carpi ulnaris, flexor carpi radialis, palmaris longus, and abductor pollicis longus (also a flexor of the wrist joint) amounts to seventeen and fifty-seven-hundredths centimeter-kilograms, according to Recklinghausen's computations. By contrast, the flexors of the fingers have a much lesser rotation moment, in respect to the wrist joint, and they do not control the terminal ranges of the articulation. Such an arrangement is very similar to that which exists between the rectus femoris and the vasti for the extension of the knee joint, the gastrocnemius and soleus for the plantar flexion of the foot, and the biceps and brachialis anticus in the flexion of the elbow.

It would seem that contracture of the wrist flexors should make for extreme flexion position. But, in purely deficiency contractures, we see that no extreme flexion position develops as it does in the spastic condition. This, again, is due to the antagonistic, passive resistance of the extensors, which increases as the flexion progresses. On the other hand, the same increasing passive resistance, or passive insufficiency, of the extensors produces hyperextension of the metacarpophalangeal articulations because the latter are more forcefully controlled by the finger extensors, due to their greater lever arm. Only by full cooperation of the lumbricales and interossei, which are the antagonists to the extensors in the metacarpophalangeal joint, can the formation of the claw hand be prevented. Indeed, in the paralytic with flexion contracture of the wrist, we see as a second step a tendency to claw-hand formation.

Paresis of the flexors of the fingers accentuates this claw-hand tendency because the finger flexors no longer assist in flexing the metacarpophalangeal articulations.

Of the greatest moment in paralytic disequilibrium is the loss of the intrinsic muscles of the hand. They are the true regulators of balance; they guard the normal equilibrium between long flexors and long extensors by neutralizing the dominating extensory effect of the long-finger extensors upon the metacarpophalangeal articulation, and by antagonizing the long-finger flexors in the phalangeal joints.

The Constitutional Propensity to Contracture. The Common Fields of Tension and Relaxation

In the strictest sense, it is inaccurate to speak of a definite point of joint position at which action between agonist and antagonist alternates. More often, the agonist has already finished its contraction before the antagonist has attained its whole relaxed length. Both muscles are, for a short space, simultaneously under tension. This space is called the common tension field. Less frequently, the antagonist reaches its relaxation for a space of excursion before the agonist has begun to contract; this space is called the common field of relaxation. Practically, it means that, in the first case, the muscles are fitted firmly to the joint, and motion is controlled; in the second case, the muscles are fitted loosely, under slack, and motion is free and limber. In the first case, the muscles are hypersufficient,—the amplitude is too small; in the second case, they are insufficient,—their amplitude is too large.

An instance of a common field of tension is the pairing of the tibialis anticus with the tendo achillis muscles. Here the common field of tension occupies no less than one-fifth of the entire range of motion. The flexors and extensors of the wrist are another instance. Here the common field of tension occupies only one-twelfth of the total amplitude. We notice that both joints require a great deal of stability. An example of the common

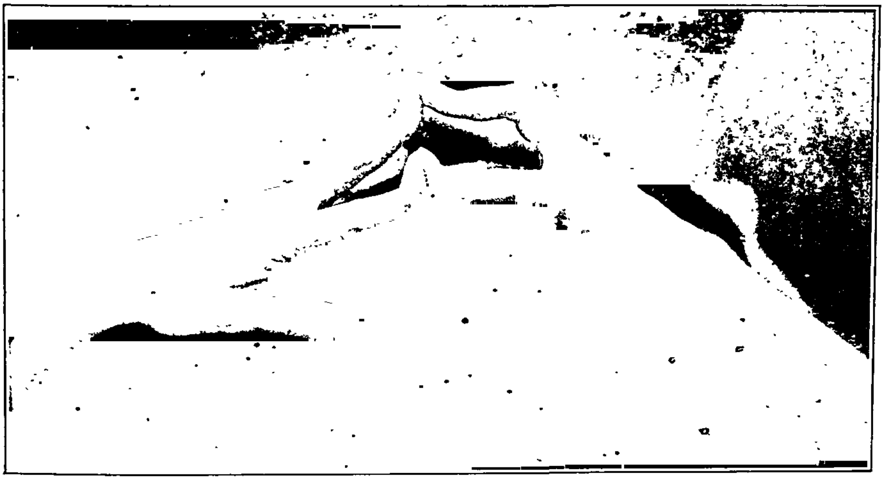


Fig. 2

Common field of relaxation between extensors and flexors. Loose fingers, constitutional.

neutral point is the pairing of the tibialis posticus with the peroneus longus.

Illustrative of a common field of relaxation are the long extensors and flexors of the fingers; here easy mobility is the principal requirement (Fig. 2). This point is of great significance for the mechanogenesis of contractures, particularly those involving the fingers. It can easily be seen that such a state of relaxation may exist as the result of atrophy, or as a natural constitutional condition. Any peripheral resistance directed toward the fingers may modify the type of contracture. We observe this not so much in paralytic as in arthritic contractures where the inflammatory atrophy adds to the relaxation.

To return to the quoted symbolic expression of the amplitude (range) and efficiency indices, it may be stated that the greater the natural length of the fiber compared to the maximum-minimum difference, the greater is the amplitude, the looser is the joint, and the smaller is its efficiency. If this quotient $\frac{L}{L\ max. - L\ min.}$ reaches the point of one and thirty-five-hundredths we speak of a common field of relaxation. When, on the other hand, the tension fields of the agonists and antagonists overlap and the muscles thereby become hypersufficient, the ratio goes below one and two-tenths. In some instances it is as low as six-tenths—in the muscles of the

FIG. 3
Extreme wrist flexion contracture of the spastic.

elbow or of the wrist, for example. In very firm-jointed individuals the coefficient may sink to thirty-four-hundredths.

II. INNERVATIONAL CONTRACTURES. SPASTIC CONTRACTURES

The introduction of the innervational element in spastic cases, either alone or in addition to actual elimination of muscle power, changes materially some of the inherent properties of the muscles. The situation becomes different enough to require special investigation of the physiomechanical premises. Aside from the intrinsic factors of subcortical dominance and lack of reflex inhibition, posture and gravity also are of considerable consequence in this type of upper extremity contractures.

The most important point in regard to spastic contractures is that the resistance of the contracted muscles is greatest in terminal position when insertion and origin are most approximated. Once this resistance is overcome, the spastic contracture yields more easily. Here is a definite contrast to the shrinkage contractures. In these, the resistance of the muscles increases with the amount of stretching, in accordance with Hook's law of elasticity.

Another point in which the spastic contracture differs from paralytic imbalance is that, owing to the enormous surcharge of innervational impulse, the contractile tone is far in excess of the normal maximum contraction. It is of tetanic type. Therefore, we frequently see extreme positions,—as in the flexion contracture of the wrist or in the pronation contracture of the forearm (Fig. 3).

A third point is the lability of the contracture position. When the first resistance is overcome, contracture is not only released but often turns into the converse contracture with astounding ease. In these cases the balance between agonistic and antagonistic muscle groups is extremely labile; some authors speak of a spasmus mobilis,—a shift of contracture position (Figs. 4-A and 4-B). The fingers may change from flexion to extension contracture,

FIG. 4-A

FIG. 4-B

Spasmus mobilis. Alternation of contracture position in spastics. Fig. 4-A showing flexion. Fig. 4-B showing extension.

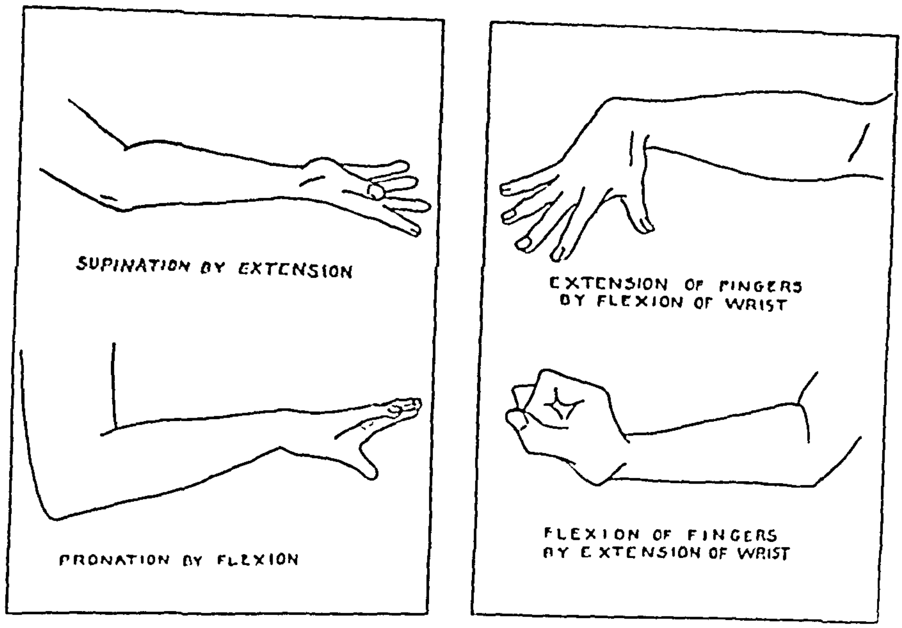


FIG. 5
Substitutionary motion of forearm and fingers in spastics.

the forearm from pronation to supination. This is one of the reasons for the difficulty in obtaining, either by conservative or operative means, permanent balance between antagonist muscle groups. In the hemiplegic, as long as the active mobility of the extremities has not returned, the formation of the contracture position depends, according to Förster, entirely upon the casual position of the limb and the perseverance in this position. But, as time passes and the position remains the same, tension in the muscle becomes greater and fixation becomes more firm. In contractures of the fingers in old cases of hemiplegia, the fingers often have an extended position against the thorax while the thumb shows adduction and flexion. There are many instances in which the opposite contracture can be seen, although adduction of the arm, flexion of the elbow, pronation of the forearm, flexion of the wrist, and the turning in of the thumb, are by far the most usual contracture positions. When voluntary motion of the antagonist returns, another factor enters into the play. In the upper extremity this return occasionally changes the flexion position, and the fingers are held in extension; or, at least, the flexion contracture of the fingers and wrist becomes mitigated. With the return of voluntary motion substitutionary motions also assume a meaning and can be used for the execution of movement which ordinarily would not be feasible. The background of this substitutionary motion for the hand is the development of passive tension and of passive insufficiency on the part of the extensor muscles (Fig. 5).

In general, the muscles most prone to contractures are those entrusted with holding posture. These are preeminently the short-bellied, uniarticular muscles,—brachialis, pronators, supinator radii brevis, and the flexors of the wrist. The pluriarticular muscles of the fingers, which have long bellies and are entrusted more with the dynamic functions, are less prone to produce contractures.

From the practical viewpoint it must be inferred that operative methods, which can only crudely redistribute balance, must encounter great difficulty in maintaining a muscle equilibrium of such extreme lability. A relief from the accumulation of efferent stimuli may be obtained by posterior root resection, or the efferent stimuli may be equalized by selective nerve resection. But these can only be preparatory steps for the all important muscle educational program. It seems, also, that the unsatisfactory results of muscle transference in this type of hand contractures can be explained on the ground of lability of balance, which makes the functional readaptation of the transplanted muscles very difficult. Reeduction of the old and opening of new and substitutionary pathways of nerve impulses by muscle training is the principal treatment. Fortunately, the hand is a very docile instrument.

III. CONTRACTURES FOLLOWING MYOSITIS. (ISCHAEMIC CONTRACTURES)

There are some physical aspects to be added to this group involving changes in the inherent mechanical properties of muscle tissue. First of all, in ischaemic myositis we deal with a true structural contracture. From its inception, it is not a contraction; it is a passive state. The relation between is otropic and anisotropic bands of cross striation is not that of the contracting muscle; it is that of the resting muscle. Also, it can be shown that the contracture is maintained at minimum expenditure,—there is no action current or fatigue.

Exact data of measurements and calculation of the changes of the elasticity in myositis, such as are found in ischaemic contracture, are not at hand; but clinical experience teaches that the elasticity is greatly decreased and the muscles offer considerable resistance to elongation. The elasticity module corresponds to that of the non-innervated, inert, muscle substance and the graph indicating the ratio between length and load shows a parabolic curve.

For practical purposes, the conclusions can be drawn that the myositic contracture will require continuous and steady counterforces for correction and that the resistance to correction will increase rather than decrease with improvement of position; this is quite in contrast with our experiences in spastic contractures.

Analysis of Ischaemic Contractures of the Hand.

Where there is no involvement of the ulnar and median nerves the contracture develops strictly on the basis of the myositic changes in the forearm and finger flexors. The sequence is usually as follows: first, there appears a flexion contracture of the wrist and flexion of the mid and end phalangeal joints; later, follows the extension contracture of the metacarpophalangeal articulation with retraction of the knuckles. The angular positions of the three finger joints do not correspond to the relation of their respective rotation moments (seven to five to one). Also, the ratio between natural fiber

length and maximum amount of shortening, which is the index for the efficiency of the muscle in its natural amplitude, has changed, due to the severe parenchymatous and interstitial degeneration of the muscle.

The hyperextension in the metacarpophalangeal articulation is largely the result of passive insufficiency of the extensor group, and need not indicate loss of interossei action. However, paralysis of the ulnar nerve often complicates ischaemic paralysis, causing the claw formation to become much more accentuated. In this case, we also see that the flexion in the interphalangeal joint is very much stronger, not being resisted by the extensory action of the interossei. The extreme flexion holds the end phalanx in immobile position, and provides practically a peripherally fixed point of application, comparable to a peripheral external resistance—the closed kinetic chain of v. Baeyer. In order to solve the problem of this contracture complex, it is above all necessary to eliminate this element of peripheral resistance and to free the phalanges from external restraint. The key to the situation is, here again, the flexion contracture of the wrist; upon it all of the subsequent features of contracture are superimposed. With returning dorsiflexion the passive insufficiency of the stretched finger extensors is removed. This does away with the hyperextension in the metacarpophalangeal joints, and is partly responsible for the extreme flexion contracture in the end phalangeal joint and for the closing of the kinetic chain.

IV. ARTHROGENETIC CONTRACTURES OF THE WRIST AND FINGERS

This type is to be considered from the viewpoint of secondary muscular involvement and its effect upon joint position rather than from the view-

FIG. 6

Arthritic wrist contracture. Extension contracture of the end phalangeal joints from peripheral resistance.

point of the primary arthritic position. In the primary contracture of the acute and subacute stage the muscles are hypertonic. It is a measure of defense to place the joint in a position which approaches the neutral point for all muscles. In tuberculosis of the wrist the position is found to be one of slight flexion and ulnar abduction.

The hypertonic fixation contractures of earlier stages of joint affections are much easier to manage because, under constant traction, they yield to resistance in a manner similar to the spastic contractures. It is very different in the later stage of true contracture, because the histological changes in the muscles make passive stretching difficult.

Most of the contractures are flexion contractures of wrist and fingers, since the preponderance of muscle power and of the rotation moments is on the flexor side. But, here also, positions are frequently found to be materially different from the expected type. Closer analysis shows that these contractures of wrist and fingers could not develop from the inherent muscle contracture alone, but that external forces—particularly gravity—and external resistances must come into play; for instance, the hand may rest against the stomach, or against the thigh. Such external peripheral resistances, which close the kinetic chain, materially influence the type of contracture. In the arthritic hand several types of contractures are seen,—extreme ulnar abduction, flexion of the wrist, hyperflexion of the fingers, and claw hand; in some cases, there is hyperextension of the mid-phalangeal articulation. The latter type is particularly interesting. As long as the finger joints are free to follow the contracting interossei, the pill-roller hand develops. The wrist must be free to assume a straight or slightly dorsiflexed position in order to relax the extensors; otherwise, no extreme flexion in the metacarpophalangeal joints could develop. Now, if the fingers meet with

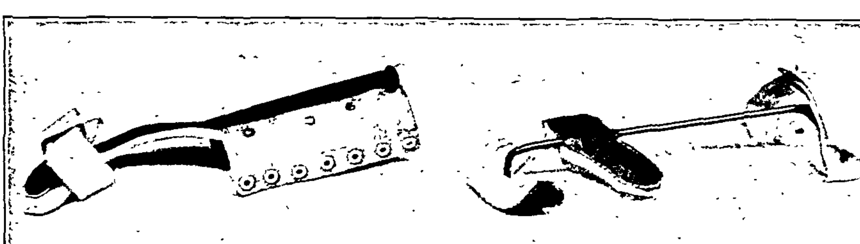


FIG. 7-A

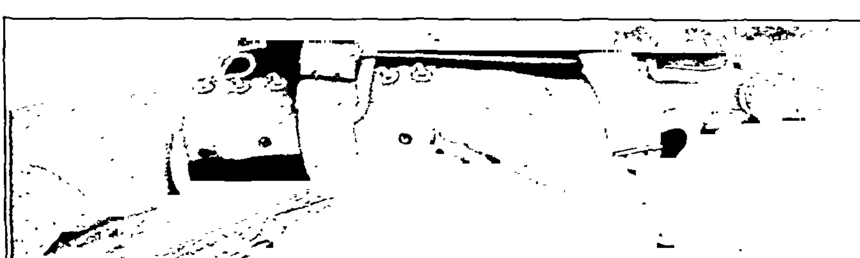


FIG. 7-B

Splint: rigid type. Three-point application principle.

external peripheral resistance, the mid and end phalanges of the fingers are forced into hyperextension. Loose-jointed fingers, made still looser by the attending arthritic atrophy of the long-finger flexors, are particularly susceptible to these external resisting forces. This is an instance where the factor of the common relaxation field assumes practical significance (Fig. 6).

V. THE APPLICATION

These theoretical points have not so much bearing upon the detailed construction of the apparatus as they have upon the policy and principles under which the management of upper extremity contractures should be carried out.

In the first place, all contractures are complexes, and they all have a basic or key contracture which, in most instances, is the flexion contracture of the wrist or of the metacarpophalangeal joints. Any of the splints and appliances which carry out the principle of three-point application will, if constructed properly, serve the purpose of gradual and consistent correction. The point is: shall it be a persistent, positional correction, comparable to the action of corrective casts; or shall it be elastic traction, such as has recently been elaborated by Mommsen in his so called "Quengel" method? From the nature of the contracture it would appear that preference should be given to the methods of elastic, continuous traction, except where a great amount of correcting force is necessary, and where the application of this traction principle meets with technical difficulties.

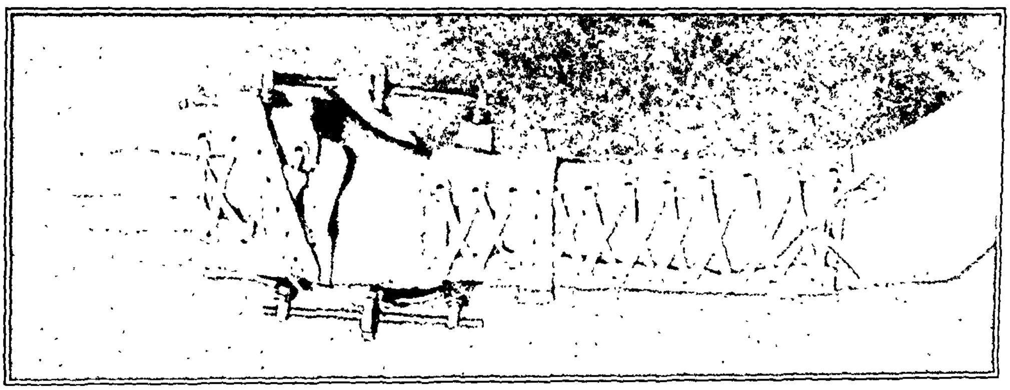


FIG. 8-A

FIG. 8-B
Wrist splint. Turn-buckle type.

From theoretical considerations it further follows that in the preshrinkage stage of contracture in infantile paralysis, and in spastic paralysis, the attainment of correction is comparatively easy; it is much more difficult in ischaemic and in late arthritic contractures. It must also be realized that the uniarticular muscles, with comparatively short muscle fibers and a greater rotation moment,—a greater "specific shortening"—will develop much more resistant contractures than the pluriarticular muscles,—*i.e.*, that pronation contractures and wrist flexion contractures are, on the whole, less easily amenable to conservative correction by apparatus.

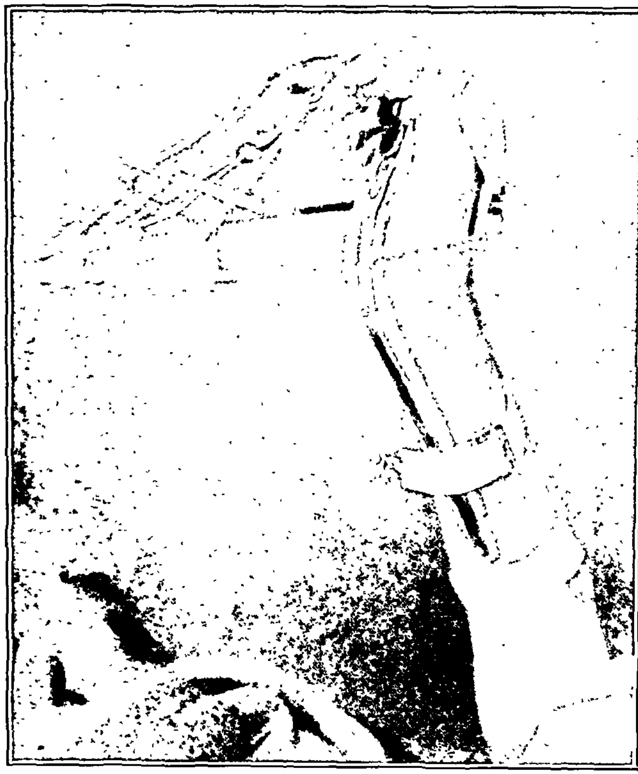


Fig. 9-A
Fingersplint: banjo-traction type.

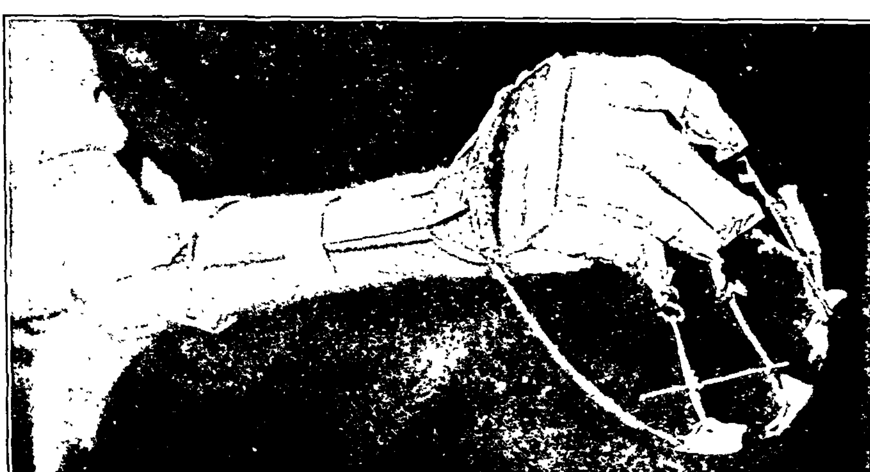


Fig. 9-B
Fingersplint: banjo-traction type.

What are the Limits of this Conservative Treatment?

Our experience in general has been that, if the conservative treatment is carried out persistently and judiciously, it yields better results and has a much greater scope of usefulness and efficiency than it is generally accredited with. This is particularly true of the ischaemic contractures. Moreover, the *conservative treatment* is the only treatment which can lay claim to a true physiological recovery by *restoring the normal muscle-fiber length* and its normal amplitude and efficiency.

A variety of upper-extremity appliances is being used. The body of the splint for the hand and finger is usually of the cock-up type, fastened to palm and forearm with straps and cuffs; the special corrective device, whether it be a flat finger splint or an elastic windlass arrangement on a banjo frame, is then superimposed upon the cock-up part. In contractures of the upper extremities, especially in those of the fingers, it is good policy to change position from time to time to avoid opposite contractures. Splint correction and muscle reeduction are at all times closely interwoven (Figs. 7-A, 7-B, 8-A, 8-B, 9-A, and 9-B).

Only after the full exploitation of the combined splint and exercise treatment, can the limits of the conservative treatment of upper extremity contractures be defined.

The Operative Release of Contractures

1. *Tendon Lengthening.* From the preceding remarks it should be obvious that the operative lengthening of a tendon for the purpose of releasing contracture does not reestablish physiological conditions. The muscle is thereby rendered too short for its tendon; whereas it previously had offered passive elastic resistance (passive insufficiency) to the restoration of the normal mid-position, it has now become actively insufficient for all, including the neutral, positions. This does not abrogate the merit of the procedure; the restoration of form is gained, but it is paid for with a certain

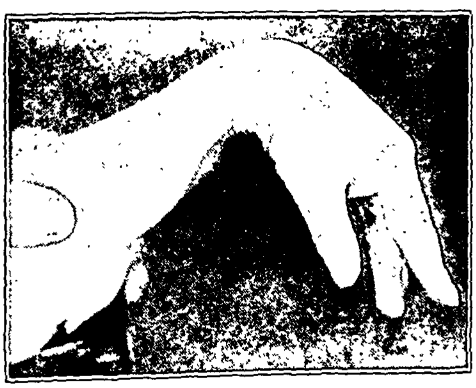


Fig. 10-A

Ischaemic contracture treated only conservatively.

Fig. 10-B

Wrist range after treatment.

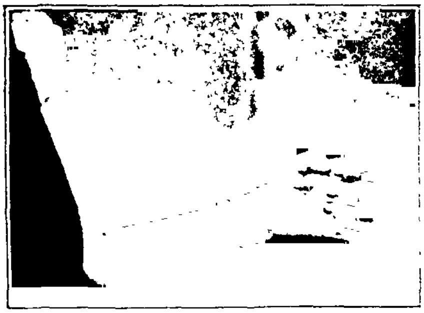


FIG. 11-A

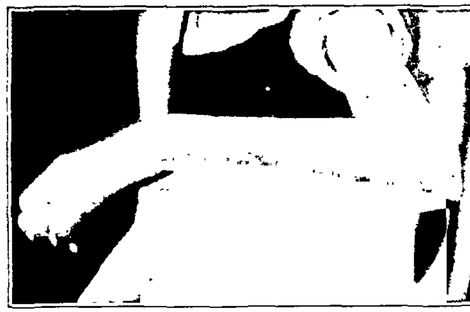


FIG. 11-B

FIG. 11-C

Ischaemic contracture treated conservatively and with lengthening of the wrist flexor tendons.

Figs. 11-A and 11-B, before treatment.

Figs. 11-C and 11-D, after treatment.

FIG. 11-D

loss of function. Still, in the upper extremity, a great deal of adaptation is possible. In any event, the operative lengthening is a last resort. Tendon-lengthening operations are performed, principally, in spastic contractures where a decrease of the muscle power is desirable,—as, for instance, in the flexion contracture of the hand and in the adduction and flexion contracture of the thumb. In cases of ischaemic contractures, it is used only to correct as much as possible the flexion deformity of the wrist; tendon-lengthening operations of the long-finger tendons are being avoided because of the loss of muscle power which this procedure entails (Figs. 10-A, 10-B, 11-A, 11-B, 11-C, and 11-D).

2. *Tendon Stripping Operation for Upper Extremity Contractures.* Here, principally, the stripping operations upon the forearm flexors and pronators are used in ischaemic contractures and contractures in spastic paralysis. The common head of the forearm flexors, together with the humeral head and the pronator radii teres, is stripped from the internal

condyle of the humerus and replaced downward, with due regard to their innervation by branches of the median nerve.

3. *Alcohol injections and motor nerve resections to overcome spastic contractures.* This is a procedure confined to the motor branches of the ulnar nerve which supplies the intrinsic muscles of the hand. It is carried out in exceptional cases—as in the strong, intrinsic muscle contracture of the arthritic —and, occasionally, in cases of spastic paralysis of the hand. Alcohol injections produce a temporary loss of the muscle tone and facilitate the treatment of the pill-roller hand contracture.

4. *Juxta-articular Osteotomies.* A few selected cases of intractable claw-hand contracture have been subjected to this procedure. An osteotomy performed just proximal to the head of the metacarpals permits a volar deflection of the joint line, compensating for the retraction of the basal phalanges.

5. *Simple myotomies.* This operation is indicated only in very special cases,—as, for instance, in order to overcome a shrinkage contracture of the pronator quadratus muscle. The pronator radii teres, on the other hand, can be stripped off or lengthened, so that the use of this muscle is not entirely lost.

These surgical procedures are merely devices to correct contractures which elude conservative efforts and they have nothing to do with the problem of restoration of muscle balance,—such as tendon transplantations and arthrodesing operations. The discussion of such procedures is outside the scope of this paper.

We wish merely to state that, in most situations, the program of release and correction of contracture should be pursued independent of that of the restoration of balance, and should certainly precede it. When the contracture is released, whether it be spastic, ischaemic, or paralytic, a new situation arises which opens wider possibilities for the rehabilitation of normal muscle balance by educational and conservative methods.

CONCLUSION

In conclusion it may be pointed out again that the stated theoretical facts have a wide practical application. They are fundamental in formulating the program of treatment, not so much in regard to the technical construction of external appliances, but rather because the pathomechanics of these upper-extremity contractures point out the causal relationship of the different components of the contracture complex. By recognizing a basic or key element upon which the whole complex is built, we can decide on the most efficient point of attack for the correction. The biophysical theory of contracture gives information also as to when and how long mechanical correction is to be applied, and what changes of position conform best to the mechanical situation. It is safe to state that only by understanding the biophysics of these conditions, can one become efficient in their management and treatment.

THE HISTORICAL DERIVATION OF THE PHYSIOLOGICAL PRINCIPLES UNDERLYING THE TREATMENT* OF FRACTURES

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Individual experiences frequently prove to be fallacious. Because of this, we can most safely determine our course from a summary of the facts accumulated on the treatment of fractures. Our objective in the treatment of these injuries, in their various locations and degrees of severity, is always the restoration of function without deformity. Only those physiological principles on which there is authority for acceptance shall be seriously considered.

HISTORICAL REVIEW

Such an approach in search of facts available on any subject requires a summary of work done. This includes related fields. The story begins in 1737 when Duhamel[1], a French lawyer, reported his first results from feeding madder to animals and fowls. Through this and later reports, he sponsored the opinion that periosteum was the maternal tissue of bone. Haller[2], Professor of Anatomy in the University of Göttingen, was stimulated in conducting similar experiments. From the results, he believed that periosteum had no osteogenic function. This was in accord with the prevailing opinion expressed with finality by the master surgeon Cheselden[3] in 1741. Bones "are covered by a fine membrane, which upon the skull is called pericranium, elsewhere periosteum. It serves for the muscles to slide easily upon; it is everywhere full of small blood vessels which enter the bones for their nourishment." The growth of bones proceeds "by the continual addition of ossifying matter; they increase until their hardness resists a further extension; and their hardness always increasing while they are growing, the increase of their growth becomes slower and slower until they cease to grow at all. In all fractured bone, in which the same kind of matter which ossified the bones at first is thrown out from the broken ends, there is formed a mass of callous matter."

It is of interest and particular significance that emphasis be placed upon these facts: Almost two hundred years ago periosteum was recognized as a vascular membrane from which the underlying bone received blood vessels. The growth of bone was not different from other living tissue which developed by a filling up and expansion of the interstices. The repair of a fractured bone resulted from the formation of callus which ossified. This summary may be accepted as an expression of that which was known about bone growth when Duhamel and Hunter began their animal experimentation and clinical observations on bone growth and reaction to injury. Thus was started a controversy which is still represented by two schools of

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thought, although constant effort has sought settlement for nearly two hundred years.

As early as 1779, there was expressed, by Jean Pierre David[1], the opinion that rest and action represent nature's two resources in the repair of an injury. Each of these opposing states had a proper time and place in the treatment of disease.

John Hunter[5], 1768, was in complete agreement with Haller. His experimental work began and ended with the conviction that periosteum had no osteogenic power, — it was a fibrous membrane surrounding bone which the blood vessels nourished. In connection with these experiments he was first to observe one of the fundamental powers of living tissue, — the removal and absorption of portions of their substance. The results of experimental work on madder-fed pigs revealed to him that "living bone is constantly changing its matter". Because of this he emphasized that normal bone growth must include absorption as well as the deposition of osseous tissue. The removal of products by absorption was shown to take place through the lymphatics rather than the veins.

Hunter then became interested in the experimental study of the repair of fractures. His conclusions were in close agreement with those of Duhamel, except that in the end he presented the broader view. Both men recognized: (1) the presence of a blood clot between the fractured ends and surrounded by a periosteal bridge; (2) the clot was seen to be "organized" by the formation of blood vessels, small arterioles; (3) these vessels came from muscle, periosteum, cortex, and endosteum; (4) as the callus grew older, bone was usually first formed at the ends of the fracture, but it also occurred deep within the callus. It will be recalled that he was a disciple of Haller, who held that bone could be formed around any arteriole. He seemed indifferent, therefore, as to where arterioles came from, — periosteum, muscle, cortex, endosteum, or medulla. These and subsequent conclusions made from animal experimentation and clinical observation formed a rational basis for those who were to follow Hunter.

Duhamel was less liberal in contending that the callus was a product or secretion of the periosteum; all adjacent structures were passive in the process of repair.

One hundred years later, 1834, Charles Bell[6] stated that "a bone may be taken to prove that in nature's work strength is given with the least possible expense of materials. Nature, solicitous of our safety, combines with the perfect muscular frame a dense and perfect texture of bone . . . . The inert and mechanical provision of the bone always bears relation to the living muscular power of the limb." This is an index of the trend of thought which, fifty years later, culminated in a more concise statement by Julius Wolff[7]. As Professor of Orthopaedic Surgery in Berlin University, he was chiefly interested in the results of careful investigation, including animal experimentation. In 1885 Wolff concluded fifteen years of work directed toward the formulation of a law governing the transformation of bone. The alteration of internal structure, which always accompanies

deformities of bone, first received his attention. Thus stimulated, his work continued until he proved the presence of secondary external changes adapted to function in the new position. In its final form, Wolff's law of bone transformation, in its usually accepted translation, reads:

> "Every change in the form and the function of bones, or in their function alone, is followed by certain definite changes in their internal architecture, and equally definite changes in their external conformation, in accordance with mathematical laws."

The results of Ollier's work at Lyons, on experimental fractures, were published in 1867[8]. He concluded that: (1) periosteum produced the greatest amount of callus; (2) the endosteum was next in importance; (3) while the cortex was the least active in restoring continuity of a broken bone. It should be noted, therefore, that this was essentially the same opinion expressed by Duhamel in 1737.

Macewen[9], of Glasgow, made a discovery which at least made this question less definitely settled. In 1878, a three-year-old, emaciated boy was brought to him with a suppurating osteomyelitis of the right humerus. The shaft was removed, leaving the distal epiphysis and a small part of the proximal end with the humeral head. Two years later, in 1880, the right upper extremity was useless. For this reason the patient was returned for amputation of the extremity. Being courageous, as well as a skillful surgeon, Macewen had an alternative course. Through a longitudinal incision on the lateral aspect of the arm, he found no evidence of regeneration in any part of the area of excision. The distance between the proximal end and the distal epiphysis was filled in with pieces of bone which had been removed from the curved tibiae of previous patients. The age of these bone fragments is not known, but it is stated that the periosteum was not on all of them. Although this operation was performed thirteen years after Lister[10] announced his discovery of wound infection (1867), the wound healed, the grafts became viable and grew into one continuous bone, connecting the proximal and distal ends, representing a total length of six inches (15 cm.); four and one-quarter inches were formed by the tibial grafts. Thirty years later; *i.e.*, in 1910, the patient was a capable workman thirty-five years of age. He had a useful, slightly curved, but well-formed humerus eleven inches (27.5 cm.) long. His right arm was three inches (8.5 cm.) shorter than the left.

It was thus for the first time shown that bone fragments may be used as grafts which become viable, develop, and form, or lead to the reproduction of, bone. We might refer at this point to Wolff's law by calling attention to the fact that these tibial grafts lead to the development of a real humerus of essential anatomical characteristics and physiological requirements.

The brevity of this review covering the development of knowledge relative to the growth and repair of bone is more necessary than desirable. While it reveals differences of opinion which still prevail, there is expressed the more important fact relative to the prevailing attitude of mind which governed the treatment of fractures.

It was during the fifteen years between 1876 and 1891 that Hugh Owen Thomas[11] created a school of thought which continues to have many followers. His doctrine of "enforced, uninterrupted, and prolonged rest" was practised as a religion. This principle was carried out by strict, systematic, and complete application in the treatment of each successive case. In the methods of promoting rest, Thomas was fastidious and critical. He insisted that while immobilization was essential for rest, its application should always be attained without constriction of the extremity or compression of its circulation. He, therefore, was always opposed to the use of plaster which was the prevailing practice in France. This conviction was not an unfounded prejudice. Thomas fortunately was Hunterian in his attitude toward the treatment of patients, believing, as we well know, that the repair of injury is an inherent property of living tissue. His earlier practice was marked by the use of plaster. From this he learned the dangers associated with swelling of the fractured extremity, impairment of circulation, sloughs, with or without long-continued suppuration and threatening loss of the extremity. The Thomas splints are known to all of us fifty years after definition of principles upon which their creation was based.

He observed that movement at the site of fracture resulted in the formation of an exuberant callus. In union of fractures, he therefore adopted the practice of percussion at frequent intervals over the line of fracture. In 1876 he introduced the method of "damming" in the treatment of delayed union of fractures, which practice was continued until his death in 1891. Twenty-seven years later, 1903, Bier[12] again started this method of treatment. He developed mechanical devices to facilitate its use and today the principle first applied by Thomas is known as Bier's hyperaemia. Thomas for a time operated on fractures of the tibia and fixed them by pegging; this method was not long continued.

Control experiments must be used to confirm the value of treatment previously based on clinical observation. The experimental work reported by John J. Morton and S. J. Stabins[13] in 1927 was the first which revealed the indications for the Thomas method of "damming" ununited fractures.

In his day the principles enunciated and so precisely practised by Thomas were given second place in England. A movement initiated in New York by H. G. Davis[14], C. F. Taylor[15], and Lewis Sayre[16], about 1864, gained popular favor with his contemporaries. It was this New York school which fostered the use of extension as a method of fixation for resting disabled limbs.

It is evident that the late nineteenth century found agreement in the principle of rest and immobilization for the treatment of fractures, although there was difference of opinion as to the methods of application.

This professional serenity proved to be of short duration. The disturbance came from France in 1867. Lucas-Championnière[17] had his attention called to a woman, age sixty-six, who suffered from a fractured

radius. Without splinting, and with no rest of the affected region, she presented a perfect result. He then treated fractures of the fibula with movement instead of by rest and splints. The following year, 1868, he visited Lister in Glasgow and returned to Paris fully converted to the importance of the new discovery. By the application of Lister's methods he began treating compound fractures. Study of the processes of bone repair and the effect of rest on the healing of fractures was then placed before him in the depths of healthy wounds. He was convinced that slight motion at the site of fracture favored acceleration more than retardation of the progress of repair. He ultimately condemned the principle of rest by immobilization as bad. This seemed to be true because he held that motion was essential for a healthy state of cartilage, ligaments, muscles, and other specialized structures upon which function of an extremity is dependent. One by one, he abandoned all splints in favor of motion and massage, except for fractures of the tibia and femur where relatively small splints gave slight evidence of effort to immobilize the part affected.

Accepting the opposing differences in principles pertaining to the treatment of fractures, professional opinion was essentially unchanged for approximately thirty years.

Such differences in attitude toward the principles underlying the treatment of fractures in the year 1890 cannot pass without a further comment. Going back one hundred years to 1788, we found Jean Pierre David with the conviction that rest and motion have respective and equally important places in rational therapy of fractures. This was followed by the doctrine of rest through complete immobilization, with little or no emphasis on the advantage of motion in restoration of function. This attitude dominated for half a century, at the end of which it was attacked by an opponent which threatened its continuation. Lucas-Championnière made rest the adversary of a healing fracture, — motion its ally. How could these opposing views be justified? Which doctrine should be followed? Undoubtedly the answer was given by David in 1788 before the question was asked in 1890,— rest and motion have respective and equally important places in the rational therapy of fractures. This has come to be the accepted point of view.

There remain two principles yet to be considered: the application of internal fixation of fractures, by (1) metal plates, and (2) the use of bone grafts and other materials for internal fixation.

These operative procedures have been rightfully praised and condemned. In 1894 Arbuthnot Lane[18] applied the first metal plate and screws to the internal fixation of a fractured tibia. This started a wave of disturbance in the quiet waters of conservatism in the treatment of such injuries.

In 1911 F. H. Albee[19] of New York introduced the use of living bone grafts as agents of internal fixation. It will be recalled that Macewen in 1880 revealed, by his classical case of the humerus, that tibial grafts from other patients might be expected to grow or lead to the development of

bone when properly transplanted. Both of these methods have merit but neither one is free from objection. That each one should be limited to selected cases is generally admitted. Their true relationship to conservative measures may not at present be dogmatically stated.

The physiological principles governing the treatment of fractures is therefore based upon the interpretation of reaction of tissues to injury. But this interpretation must be made in terms of the functions served by all the tissues in the affected region.

Trauma, direct or indirect, sufficient to produce a fracture, must of necessity injure to varying degrees the surrounding soft parts. Such injury means solution of continuity of bone with laceration or elevation of periosteum, plus damage to adjacent muscles, tendons, fascia, directly or indirectly involving these structures, and the cutaneous surface by subsequent swelling due to hemorrhage.

The purpose which this summary serves is to make articulate some practical working plan for the treatment of fractures.

The principles enunciated by Thomas are still practiced by his son-in-law, Sir Robert Jones, in Liverpool. There is general acceptance of the favorable influence of anatomical reduction on subsequent union of a fractured bone. This includes restoration of the normal axis of the extremity by proper alignment with consequent protection of joint movement from abnormal strain, and the preservation of unaltered lines of contraction for the adjacent muscles. It is granted that the restoration of function without deformity is most assured when these conditions prevail. The question which has confronted the profession, since the requirements were recognized, is: By what treatment can we be most assured of creating these conditions?

The first expression of an effort to answer this important question was revealed in 1911. This was sixteen years after Lane had first used metal plates in open reduction. The British Medical Association[20] appointed a commission to investigate for comparison of results by treating fractures by: — (1) manipulation and immobilization by use of splints; (2) direct operation; and (3) massage and immobilization.

Two years later, 1912, the answer was given. The result of treatment was based upon the age of the patient and included 147 cases treated by Lane's method together with 2596 cases in which conservative or non-operative therapy included the usual methods of immobilization. The figures revealed that operation or open reduction was contra-indicated in patients under fifteen years of age. The statistics favored open reduction in adults.

This report may have been influenced by the advantage given by open reduction for securing absolute anatomical reduction. The inter-relationship of adjacent structures in an extremity is an anatomical fact. Normal function subsequent to a fracture can be most assured only when perfect method aims at the direct restoration of the original relationship. When attained, there is prevented the necessity of nature making changes in all

adjacent and related parts to conform with shortening or malalignment. This attempt of the surgeon to give nature every advantage to produce a perfect result seemed theoretically perfect. The intervening years have revealed limitations so that today it is usually agreed that open reduction, with or without Lane plates, is not the first method to be considered in the treatment of fractures.

The second evidence of a conscientious group effort to answer the question of how to treat fractures was expressed in April 1922. Twenty-six men, representing eight states, held a conference in Boston. A syllabus in the form of an Outline of Treatment of Fractures was presented and agreed upon. To those of you who have problems in this field it would probably prove helpful. The report was published in *Archives of Surgery* VI, 172 (January 1923).

I quote from the article as follows:

"I. First Aid.

Every effort should be made to avoid any injury additional to that of the original trauma.

1. 'Splint 'em where they lie.'
2. Avoid every unnecessary manipulation.
3. Transport with extreme care.
4. Treat any existing shock.

II. Examination.

As complete and thorough an examination as possible should be made without causing any additional injury.

1. Begin with painless procedures.
2. Search for crepitus and abnormal mobility only when these symptoms are absolutely essential. The manipulation required to elicit these may cause additional injury.
3. Rule out, if possible, other associated injuries, especially those of nerves.
4. Elicit objective symptoms, which will be painful, only under an anaesthetic.
5. Roentgen-ray examination should be made as early as possible; roentenograms should be taken in two planes, stereoscopic when necessary; should be of sufficient size, and should be studied with detailed care.

III. Diagnosis.

The simple diagnosis that a fracture exists is not sufficient. All details of pathology of the soft parts, as well as of the bone, should be considered, so as to visualize properly the problem of obtaining and maintaining reduction as well as the problem of repair and its probable duration.

IV. Treatment.

Each fracture should be considered as an individual problem and the treatment directed not only to the injury of the bone but to that of the soft parts as well. The pathologic changes following a fracture interfere markedly with the ease of reduction of displaced fragments. These changes begin very soon after the injury. Infiltration of the adjacent soft parts, coagulation and later organization of the blood are the most important.

1. Obtaining Reduction.
   (*a*) Reduction of any existing displacement should be made as soon after the injury as possible, without waiting too many hours for the roentgen-ray examination.
   (*b*) Reduction should be as gentle as possible.
   (*c*) Reduction should be as complete as the individual case requires.

(d) Reduction may be controlled by fluoroscopic examination in appropriate cases.
(e) Reduction should be checked by roentgen-ray examination as soon as practical.
(f) Manipulation should be carried out under an anaesthetic with but few exceptions.
(g) Further attempts at reduction should be made as soon as the need is recognized.

2. Maintaining Reduction.
(a) Decide in each case the peculiar problem presented, and select apparatus accordingly, both for immediate and subsequent use.
(b) A decision should be reached as to how early such apparatus can be temporarily discarded to allow for massage and motion, and how long it should be worn, in order to protect against further injury.
(c) Repair in cancellous is more rapid than in cortical bone.
(d) Rapidity of repair will depend very largely on the blood supply of the fragments.
(e) The atrophy of disuse must be borne in mind.
(f) The inherent value of any apparatus is of less importance than the skill with which it is used.

3. Plaster-of-Paris.
Circular plaster bandages are permissible only when completely divided in at least one line.

4. Massage and Movements.
If carefully and gently carried out, massage and movements can be of the greatest help. If roughly performed, they may do considerable harm. One must differentiate under massage, between:
(a) Gentle stroking without deep pressure.
(b) Stroking with deep pressure.
(c) Kneading.
One must differentiate between:
(a) Guided active motion.
(b) Unaided active motion.
(c) Passive motion.

With these differences in mind, the various forms of each may be begun as soon as there is no danger of any additional injury or any displacement of the fragments resulting. This gentle massage and movements may cause discomfort but should never cause actual pain. The pain of forced passive movements usually means harmful stretching or tearing of soft parts, with additional necessary repair.

V. Operative Treatment.
Operative treatment is indicated when a satisfactory reduction cannot be obtained and maintained by non-operative methods, provided there is no contra-indication, and when the expected result of the open method is sufficiently better than that of the closed to justify the additional risk.
Furthermore, it is generally recognized and accepted that, in certain types of fractures, it is impossible to obtain satisfactory restitution except by operative methods. The operative method is recommended to those surgeons who have had special training and experience, who have the necessary skill and judgment, and who have the hospital facilities and surgical armamentarium with which to do this work properly. In the case of those who do not have such facilities, operation is not advised.
Internal splinting of long bones is usually best made by fixation, with steel plates and screws, having a minimum of foreign material but with maximum strength and ductility. The machine type screw only should be used. The wood or so

called carpenter screws are contra-indicated in the cortex of bones. A scrupulous non-hand touch contact technique should be carried out with strict attention to detail. The skin should be carefully covered during the operation, and there should be special care and preparation of the skin before operation. Intramedullary fixation by bone graft or splints is contra-indicated if any other method is possible. Bone grafting is indicated chiefly in loss of substance and pseudo-arthrosis. It is not indicated in the treatment of acute fractures. Every attempt to stimulate osteogenesis should be exerted before attempting to bone-graft for delayed union.

VI. Compound Fractures.

In all compound fractures patients are to receive tetanus antitoxin.

Compound fractures in which it is perfectly evident that the wound of the soft parts is made by the protrusion of bone from within outward through the skin and in which the wound is tiny, should have a thorough preparation of the skin by washing with benzin, shaving (away from the wound), drying with ether and the application of tincture of iodin to the skin and the wound itself, with sterile dressing. Immediate reduction should be undertaken when indicated.

When a roentgen-ray examination is to be made before reduction, all the steps enumerated above, except reduction, are to be completed before the patient is sent to the roentgen-ray department.

In extensive compound fractures with a large wound:

1. Apply a tourniquet only when it is obvious that some large vessel has been lacerated.
2. With a sterile sponge, carefully protect the wound from contamination while the skin is being cleansed, following the foregoing routine; in addition, chlorinated soda solution 1 to 40 may be found of value in removing grease. If this procedure can be undertaken without too much pain and shock to the patient, it should be carried out before he is sent to the roentgen-ray department; if not, apply tincture of iodin only to the edges of the wound, and put on a large sterile dressing before roentgen-ray examination, and complete the procedure when the patient is under anaesthesia.
3. At operation, débridement:
   (*a*) Thorough exposure of wound by generous incisions.
   (*b*) Excision *en bloc* of traumatized and infected tissues.
   (*c*) Excision of skin at least 0.5 cm. from the wound edges.
   (*d*) Dead and dying fat, fascia, and muscle cut away with sharp instruments until fresh bleeding occurs.
   (*e*) Small bone fragments unattached to periosteum removed; soiled bone surfaces rongeured.
   (*f*) Hematoma dissecting between muscle planes should be carefully evacuated.
   (*g*) Frequent changes of gloves and instruments to insure against carrying infection into deep portions of wound.
   (*h*) Irrigation of the wound with salt solution to wash out particles of dirt, if necessary.
4. Final dressing of wound, according to indication:
   (*a*) Complete closure after lavage with ether or iodin.
   (*b*) Application of Carrel tubes for immediate use of surgical solution of chlorinated soda (Dakin's solution)."

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CONTRACTURES OF THE HAND FROM INFECTIONS AND INJURIES*

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Contractures of the hand usually result from infections. The infection may be primary or may follow traumatic tissue destruction. Contractures from burns involve essentially the skin and many include some deeper tissues. They are from without inward; while those from infections are primarily of the deeper tissues and secondarily involve the skin, either as the result of sloughing through, or because the incisions for drainage were placed so that they crossed flexion creases.

EFFECT OF INFECTIONS

Stage of Destruction

The longer the infection lasts the greater is the growth of granulation tissue and consequently the greater eventual cicatricial contraction. Therefore, we should terminate our infections quickly by accurate diagnosis, by choosing incisions which will drain each fascial space or tendon sheath adequately and still never cross flexion creases at right angles, as this leads to flexion contractures. We should, therefore, never make the median longitudinal incision whether in finger, palm, or wrist. Incisions should in the fingers be mid-lateral; in the palm parallel to the flexion creases and L-shaped for open drainage, and, if the wrist must be crossed, it should be done in a curved or zigzag line to avoid contracture. During the healing functionating positions should be maintained by splints, and intermittent exercise instituted early. The greatest damage from infection occurs in enclosed tunnels,—such as in the wrist or fingers. When tissue in such an inclosure swells, blood is excluded and ischaemia occurs, resulting in necrosis and sloughing.

When the palmar space is infected, the intrinsic muscles of the hand become paralyzed by being bathed in pus. This upsets the muscle balance and claw-hand results. As infection travels up along the ulnar nerve in the forearm, these same muscles are further paralyzed, resulting in increased deformity.

Stage of Healing and Contraction

The inflamed and granulation tissue throughout the hand and forearm gradually contracts, binding all of the tissues together in a dense octopus-like contracting scar. Just as the area of skin involved may shrink to two-thirds or one-half its size, so the deeper tissue—including deep fascia, palmar

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fascia, and the deep connective tissue which surrounds all structures—solidifies, shrinks, and draws to itself from all directions. Infected muscles shorten as they contract with fibrosis and also the parts of joint capsules which were involved in the infection. Tendons are reduced to contracting scars and attach themselves to the surrounding tissues. Tendon sheaths greatly proliferate and attach themselves to their surroundings and contract. Thus, all of the tissues may share in drawing the joints into flexion. This in the hand applies particularly to the wrist, the cleft between the first two metacarpals and the distal two joints of the digits.

Secondary Effects of Contractures

The infection follows blood and lymphatic vessels and nerves, especially the ulnar nerve. Granulation tissue forms around these structures and in the final contraction strangles them, impairing their function. The lessened nerve supply results in atrophy of all of the tissues, stiffening of the joints, and adherence of tendons. The lessened blood and lymph supply results in impoverishment of tissues, oedema, and cyanosis. The whole hand becomes firm, atrophic, cyanotic, and poorly nourished. In this so called congealed hand the joints become stiffened and the tendons adherent; and there is pain, paraesthesia, and diminished sensation.

In skin the irritation of the scar from intermittent tension results in keloid formation. Thus, where a scar crosses a flexion crease, every effort of extension increases the keloid formation and this, in turn, the contracture. The same is true of the deep cicatrix from connective tissue and in some people more than in others Secondary to contractures, muscle balance is upset. While one group of muscles is overstretched and weakened, the opposing group is allowed to contract and become fixedly so. In flexion contracture many tissues are involved. Some are primarily affected and others, including all from the skin to the capsules of the joint, follow secondarily, due to the flexed position.

The Rôle of Tendons in Contractures

A sloughing tendon is eventually replaced by a contracting cicatrix which attaches to the surrounding tissue and draws the joints into flexion. The tendon sheath proliferates greatly, and similarly attaches itself and contracts. Such a firm cord cannot be drawn out by continuous traction. Physiotherapy is useless. The damage found at operation is always worse than expected. Though the terminations of tendons left from sloughing always become fixed, severed tendons not in the presence of infection remain free or fixed according to whether they are severed in a sheath or in a paratenon formation. If severed in a sheath, the tendon ends will be found rounded over and without proliferation and free in the sheath. If severed in paratenon, however, the tendon will send out a pseudopodium which may be an inch or two long and considerably thicker than the tendon itself. This pseudopodium will attach itself firmly to whatever it touches and anchor the tendon end. If the tendon is severed where there is no

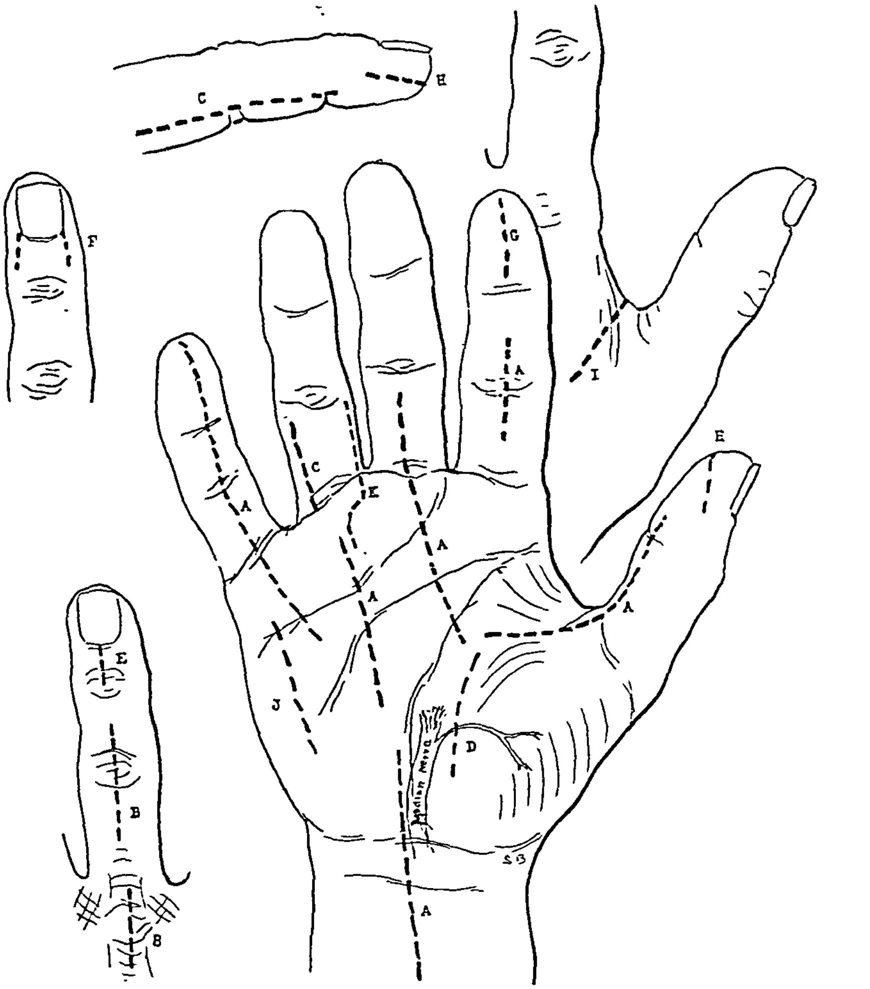


FIG. 1

A chart of pernicious or incorrect incisions in the hand, any of which will do harm.

A. Median longitudinal incisions which cross flexion creases at right angles and result in flexion contractures. These are prevalent but pernicious.

B. Median incision on dorsum of finger which later leaves a scar that contracts and hinders flexion of the finger. When present, it is impossible to fashion a proper skin flap under which to repair the extensor tendon.

C. Anterolateral incision in finger which is directly over and endangers the vessels and nerve. It is the usual one pictured for draining tendon sheaths, but should instead be mid-lateral.

D. Incision which thoughtlessly severs the motor thenar nerve and so robs the thumb of the power of opposition.

E. Median longitudinal incision through matrix will produce a ridged nail.

F. Incisions for paronychia often pictured, but erroneous, as they do not drain the bottoms of the clefts formed by the borders of the base of the nail which curve strongly forward.

G. Median longitudinal incision in pulp for drainage of a felon. It will not drain, as due to cleavage planes the pus progresses in spite of it and points dorsilaterally. Also, the scar resulting is in the tactile surface.

H. Alligator-mouth incision wrongly placed too far anteriorly which leaves a scar in the tactile surface.

I. Incision across a web injures the web which itself has a function of complicated foldings to allow for movements of thumb.

J. Incision often made for drainage of pus in sheath of tendon to little finger. The tendons, however, converge sharply in palm to pass between the ridge of the trapezium and the unciform process of the unciform bone.

K. Incision continuous from finger to palm severs nerve, thus rendering half of finger

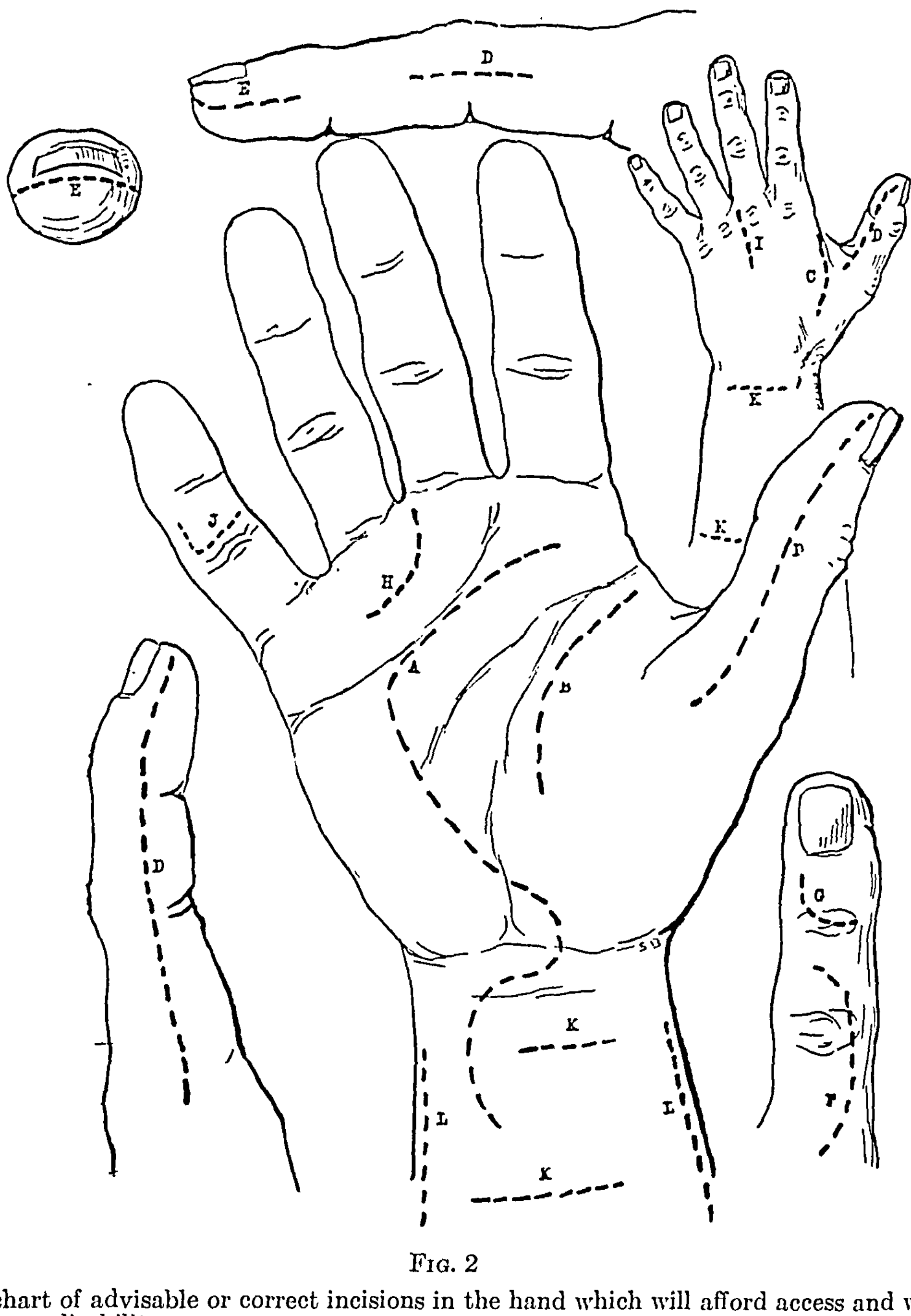


Fig. 2

A chart of advisable or correct incisions in the hand which will afford access and will not cause disability.

A. Incision for approach into palm for drainage of middle palmar space. It parallels the flexion creases, except in the immovable part or heel of the hand, allows wide opening by a triangular flap and can be prolonged so as to separate without severance the branches of the median nerve from those of the ulnar nerve. It may then be extended up through the annular ligament at its ulnar edge and up the forearm, as shown. It crosses the flexion crease in the wrist in a curve so as to avoid resulting in flexion contracture.

B. Incision for draining thenar space. It parallels the thenar crease, must not sever the thenar motor nerve and must leave pedicles sufficiently wide to nourish area of skin between it and incision for middle palmar space abscess.

C. Incision for part of thenar space dorsal to adductor muscles of thumb. It should be radial to the first interosseus muscle and stop short of cutting the radial artery as it passes through the first cleft.

D. Mid-lateral incisions in fingers and thumb which avoid volar nerves and vessels and do not produce flexion contractures. If made intermittently opposite the joints the annular ligaments or pulleys which are opposite the centers of the phalanges will be spared.

FIG. 2—*continued*

E. Incision for draining pulp abscess. One should cut across lateral fat columns, be posterior to tactile surface, and not cause tenosynovitis by nicking the sheath of the flexor tendon.

F. Flap incision for approach to extensor tendon in finger, so that the incision will be remote from the tendon.

G. Incision for approach to insertion of extensor tendon.

H. Palmar approach to collar-button abscess to give open drainage. Avoid cutting nerve to finger.

I. Dorsal approach to posterior part of collar-button abscess. It does not overlie the joint or tendon.

J. Flap incision for subcutaneous abscess. One arm should be median to nerve; the other blocks the upward progress of the infection.

K. Incisions in forearm for reaching tendons should parallel the fine wrinkling of the skin to be inconspicuous eventually and to avoid keloid formation.

L. Incisions for drainage of quadrilateral space in forearm. Entrance should be just anterior to bones and anterior to the radial nerve and posterior to the dorsal branch of the ulnar nerve.

gross paratenon but merely a thin slippery layer, as is seen in the palm, even here a thick, translucent, jelly-like tube, with walls one or two millimeters in thickness, will soon extend out as a pseudopodium and attach. Thus, if a tendon end or part of a tendon end not in a tendon sheath is "unsatisfied", it will by growth reach out and firmly attach itself. In an end-to-end suture of a small tendon to a large one, care should be taken to enclose the unsatisfied part of the large end or it will reach out as a pseudopodium, become attached to the surrounding tissues, and prevent motion. If one tendon becomes so attached, it will hold back the common muscle which pulls the tendons of the other fingers, and so will limit the action of all of the tendons. This is also frequently seen after amputation of a finger. The tendon attached to the stump has too short an amplitude of motion to allow full motion of the tendons of the other fingers. Also, attachment of a tendon will limit the action of its antagonist, whether it be flexor or extensor, and so will result in a contracture. The distal end of a flexor tendon left in a finger will contract and draw the finger into contracture. That part of a flexor tendon distal to an attachment always becomes adherent throughout the length of the finger.

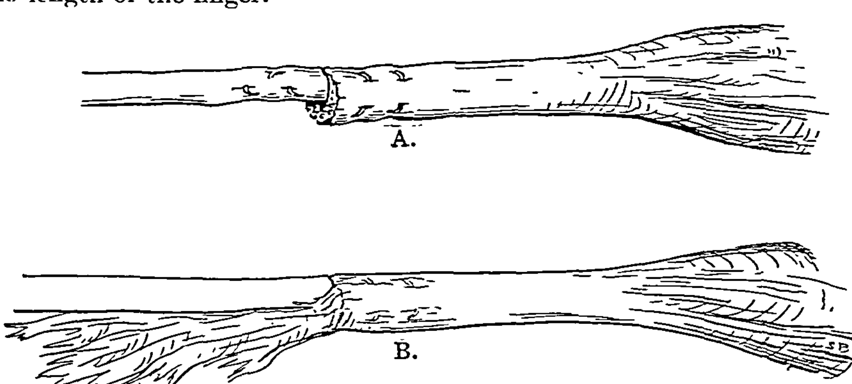


FIG. 3

If there is left an "unsatisfied" end of a tendon, or, in suturing together a small and large tendon, part of the latter end is left exposed or "unsatisfied" (*A*), that part will grow principally from its epitenon a pseudopodium (*B*), which will reach out and attach itself to the surrounding tissues and contract, so that the motion of the tendon will be checked.

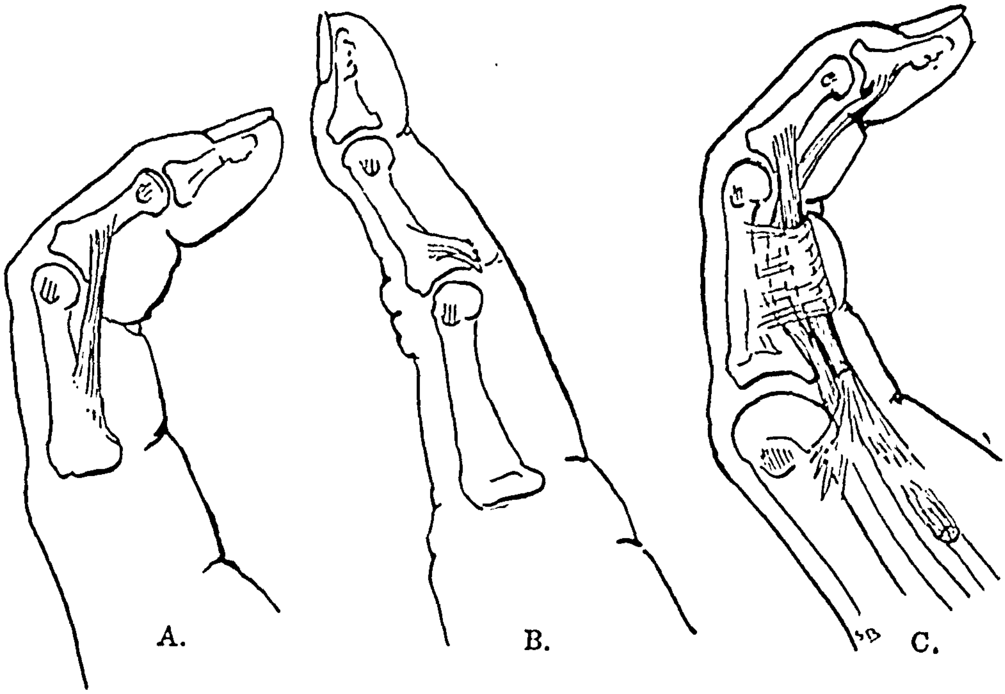


FIG. 4

In reconstructing tendons in a finger, usually the sublimis tendon must be removed in order to prevent inevitable adhesions between the sublimis and profundus tendons. The sublimis tendon flexes the middle joint and the profundus tendon the distal joint. *Therefore, adhesions joining the two tendons will prevent action of the profundus tendon on the distal joint.*

A. If the sublimis tendon is cut off too long, the distal end will attach itself to the proximal segment of the finger and draw the middle joint into flexion contracture.

B. If the sublimis tendon is cut off too short, the middle finger joint will overextend.

C. If the sublimis tendon is severed in the palm or base of a finger, the end of its distal portion will proliferate, attach and contract, producing a flexion contracture of the finger.

Volkmann's Ischaemic Contracture as a Factor in Infections

Volkmann's ischaemic contracture is unique because of the mechanism of its production. The deep fascia of the flexor aspect of the forearm, together with the bones and the interosseus membrane, constitute the tough wall of an enclosing space incapable of expansion and similar only to that enclosed by the dura mater. In the latter, decompression operations are done to prevent the brain from being damaged from ischaemia due to swelling following contusion or hemorrhage. A similar mechanism applies to the forearm and that is why Volkmann's ischaemia is found in this site only. When intense swelling occurs in this space, due usually to vessel obstruction from unreduced supracondylar fractures, and also from any cause—such as contusion, extremes of temperature, or infection—the contents of the space so swell that ischaemia is produced and consequently necrosis and partial necrosis of all of the contents of the space. Muscles are affected most, but nerves and other structures are not spared. After the initial intense inflammatory reaction and absorption of products of necrosis, contracting fibrosis occurs. The muscles undergo fibrous degeneration and are short-

ened; all tissues are bound together in cicatrix and the nerves are damaged and strangled, resulting in paralysis, glove anaesthesia, and atrophy. With this conception of Volkmann's ischaemia, it is not surprising that the process is a factor in any severe infection in the forearm.

TREATMENT

General Principles

Conservative methods of treatment alone—such as long continued, constant, mild traction—will draw stiff joints into functionating positions, will elongate soft cicatrices and contracting muscles, but will not draw out adherent cicatricial tendons; nor will physiotherapy, even if used by the

Fig. 5-A

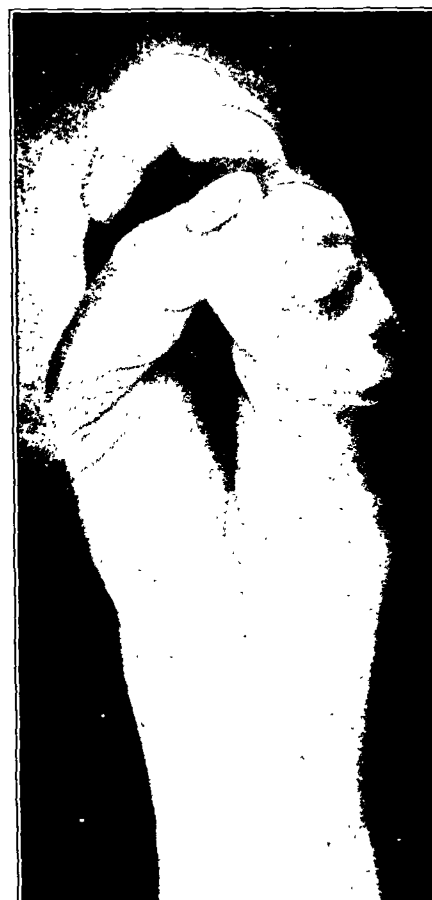


Fig. 5-B

A.T. Showing the great improvement in the nutrition of the hand produced by dissecting out all of the deep cicatricial tissue from within the hand. This octopus-like internal scar bound blood, lymph vessels, and nerves, causing the poor nutrition shown in Fig. 5-A.

The hand had been almost severed by a buzz-saw, following which infection developed. The tendons and nerves sloughed out, robbing the hand of all motion and sensation, except that supplied by the radial nerve.

Restoration of good function was accomplished by repair of the nerves and tendons, but the point exemplified here is the improvement in nutrition as shown in Fig. 5-B, due mainly to excision of the deep cicatrix.

year. The traction method is advisable for mild cases and for preliminary use in the more severe ones. It will place stiff joints in functionating positions, so that the patient can use the hand and thus will improve it by exercise.

In contemplating repair of the contracted hand, we should first picture in our imagination the normal hand with a clear conception of its anatomy and physiology. Only then can we perceive and calculate the defects in skin and deeper structures, nerve, lymph and blood supply, muscle balance, and nutrition. Our conception of the hand should include the range of motion of each joint and of the hand and digits as a whole, and also function from a practical standpoint. In normal muscle balance between the intrinsic muscles of the hand, long flexors, and long extensors, the hand assumes the functionating position with the wrist in dorsi-extension, proximal finger joints in flexion, and the thumb in opposition.

The creases and folds in the skin are each for the definite purpose of accommodating movements so these may be executed throughout their full range without resistance of binding or friction. The crease terminating the palm is merely a fold or plica to aid in accommodating for the one to one-half inch change of length of the palm in flexion and extension, but the two distal creases in the palm are opposite the proximal finger joints and allow for their flexion. The distal one of these is for flexion of the three fingers on the ulnar side of the hand and the more proximal one is for the three on the radial side, as these parts of the hand are often used separately. The thenar crease is to allow for opposition of the thumb. The fold assumed by the web of the thumb is fascinating, in that it may be longitudinal, oblique in one direction, oblique in the other direction, or transverse, according to the position of the thumb. Redundancy over the knuckles, the purpose of fine wrinkling of skin, the complex structure and mechanism of the inner parts, and many other points can be mentioned to make up a clear composite picture or conception of the normal hand. With this in mind we can better realize the defects and problems involved in the hand to be repaired.

Our first procedure is to furnish new skin and to correct the contracture. The structures inside the hand are liberated by substituting for the tight, binding cicatrix good, pliable skin by the use of the tubular pedicled skin graft. This results in marked improvement in the general circulation and nutrition of the hand. At this procedure sufficient of the deep cicatricial structures is excised or severed to overcome the contracture of the joints and the hand is placed on a previously prepared metal splint and the skin graft applied. Tendon grafting or repair is omitted at this skin-grafting stage for fear of infection.

Frequently the contracted joints cannot be extended at once, because the nerves have shortened. By gradual continuous extension, however, over a period of a few weeks, they will readily elongate.

The second operation is done a few months later, when the new skin will have sufficient vitality. At this time the deep structures are repaired.

FIG. 6-A

FIG. 6-B

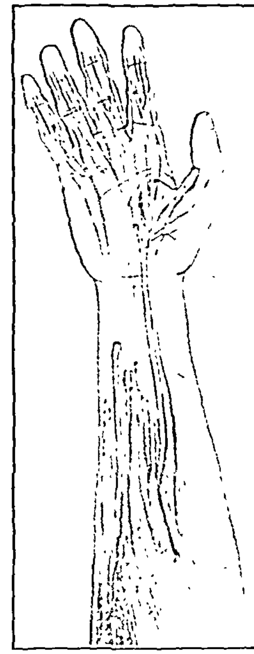


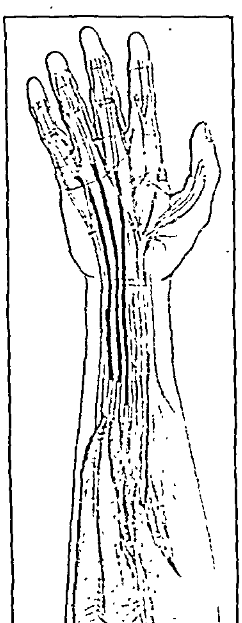
FIG. 6-C

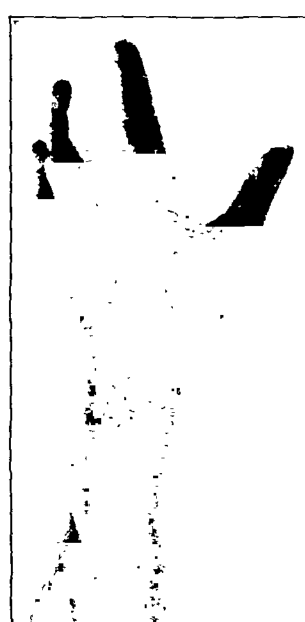
E.P. A shotgun discharged at close range into the volar aspect of the palm and the carpus. Infection followed. Tendons sloughed out. Flexion contracture and total disability of the hand resulted, as shown in Figs. 6-A and 6-B, which show the extremes of voluntary flexion and extension of the wrist and digits. There was no motion by any flexor tendon. The ulnar nerve and part of the median nerve were severed.

The cicatrix was excised and replaced by good pliable skin by a tubular pedicled graft from the abdomen. The deep cicatrix was also excised. The improvement in nutrition is shown in Figs. 6-E and 6-F.

Fig. 6-C shows the condition of the tendons and nerves found at operation and Fig. 6-D shows the repair of the tendons by freeing some, by placing tendon grafts in others, and by suturing the nerves.

Sensation throughout, good nutrition, excellent motion, and ability to work resulted, as shown in Figs. 6-E and 6-F.





The tendons, nerves, and vessels are not only dissected out from scar tissue, but the extensive, deep, connective-tissue cicatrix, which reaches out like an octopus with all its tentacles and binds and strangles, is excised until only good tissue is left, as cicatrix in healing makes more cicatrix. By freeing the nerves from encircling scar and liberating all the deeper tissues, great improvement in the nourishment and trophic effect in the hand results.

Joints

Joint capsule if still holding in contracture should be severed or excised in its shortened part. Usually, if merely severed, the edges will rejoin. If the proximal finger joints are destroyed, serviceable joints with about seventy degrees of motion can readily be made by arthroplasty. The car-

FIG. 7-A

S.T. While this man was drawing a shotgun toward him, the charge entered the palm and forearm. Infection followed, and the flexor tendons of the palm and forearm and six inches of the median and ulnar nerves sloughed out.

Fig. 7-A shows the contracted and totally disabled hand after healing, and also the tubular pedicle of abdominal skin ready for grafting. There was no motion or sensation in the hand except from the radial nerve and the extensor tendons.

Fig. 7-B shows the condition found at operation after dissecting out the cicatricial tissue. There are wide gaps in all the flexor tendons and in the median and ulnar nerves. The pedicled skin graft was applied and later tendon grafts from the extensors of the toes and nerve grafts from the sural nerves were placed, as shown in Fig. 7-C. A pulley operation was also done, as shown, to regain opposition of the thumb.

Good function resulted, as shown in Figs. 7-D and 7-E, and the patient was able to return to work as a welder.

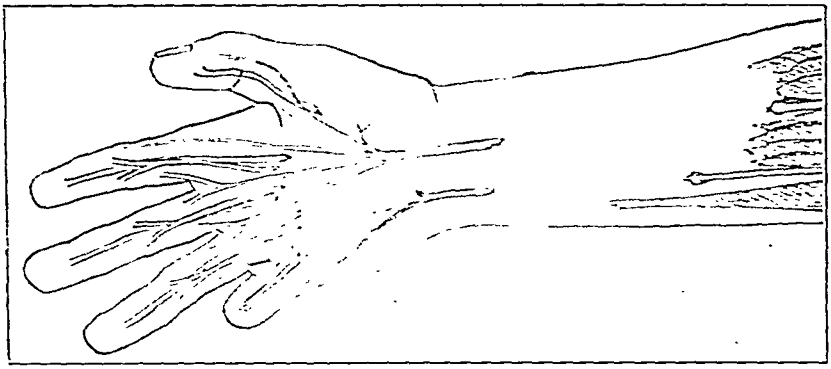


FIG. 7-B

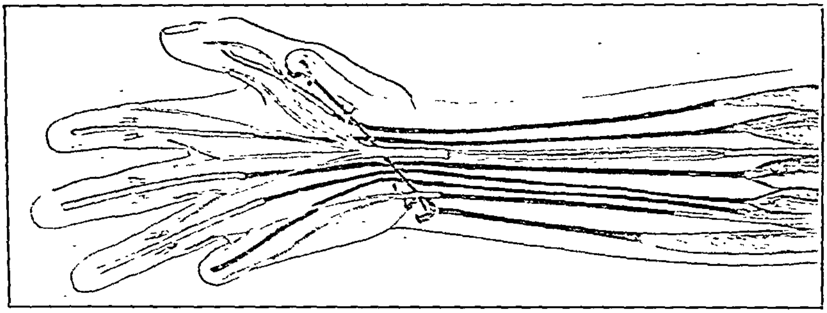


FIG. 7-C

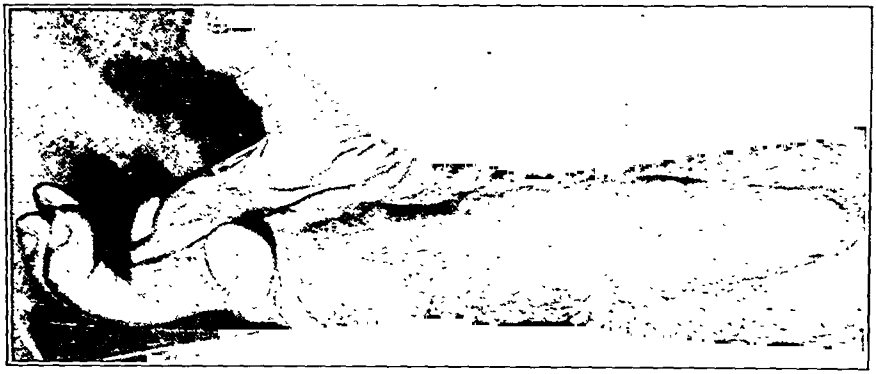


FIG. 7-D

FIG. 7-E

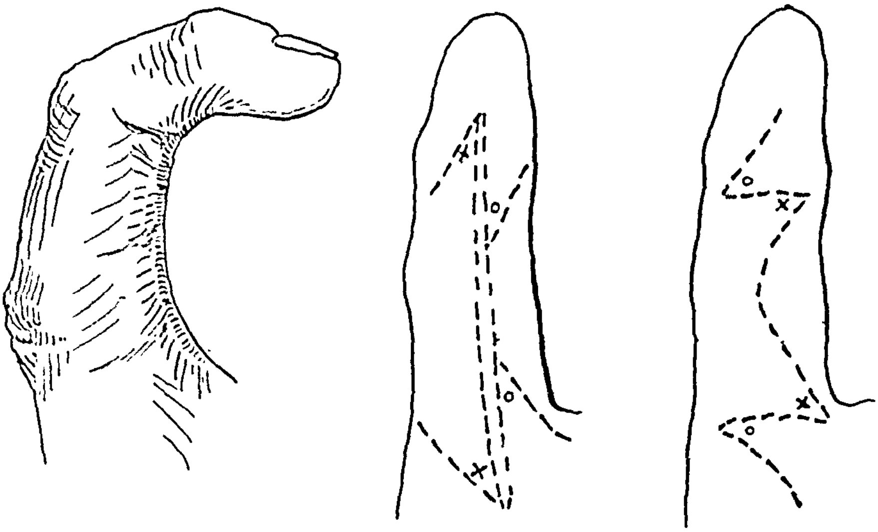


FIG. 8-A

Showing method of relieving the linear flexion contracture of a finger which results from the "pernicious median longitudinal incision". The transpositions of the flaps in the zigzag plastic are indicated by *X* and *O*.

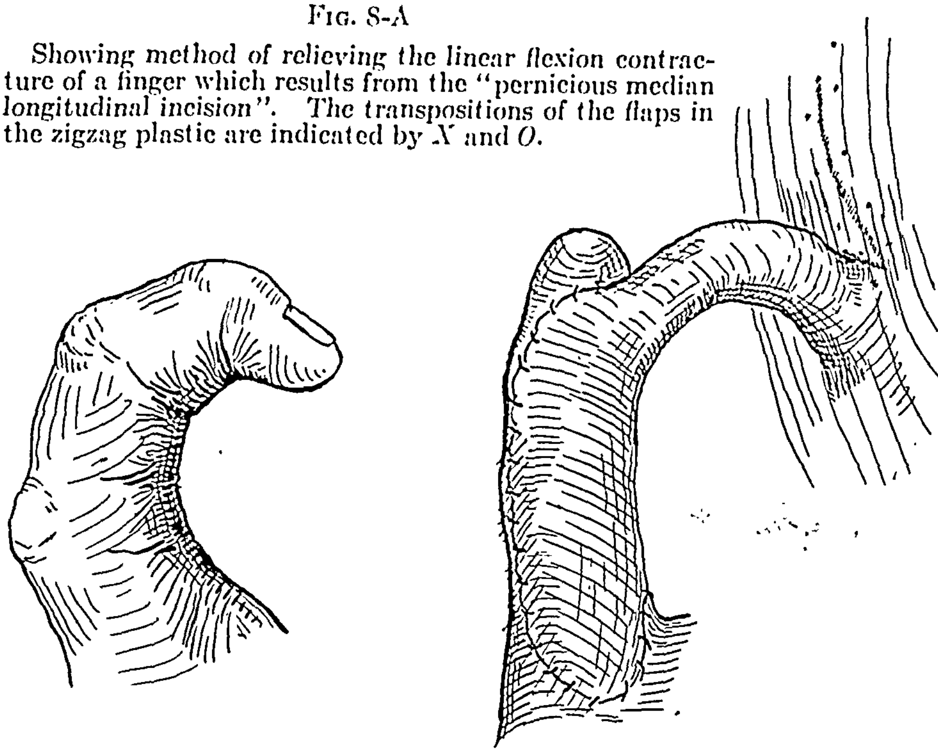


FIG. 8-B

Method of relieving a severe degree of flexion contracture of any joint by substituting for the cicatrix good pliable skin by a tubular pedicled skin graft. The borders of the skin graft should not cross flexion creases at right angles or contracting keloids will develop.

pus may have become ankylosed in poor position or may have only a small amount of painful motion. It is then advisable either to reankylose it at thirty-five degrees of dorsi-extension or to remove the proximal row of carpal bones, together with the head of the os magnum, and make an arthroplasty. The latter gives a very serviceable wrist, but is dependent on the presence of good power of dorsi-extension of the wrist by the extensor carpi radialis muscles and the extensor ulnaris. Arthrodesis in dorsi-extension

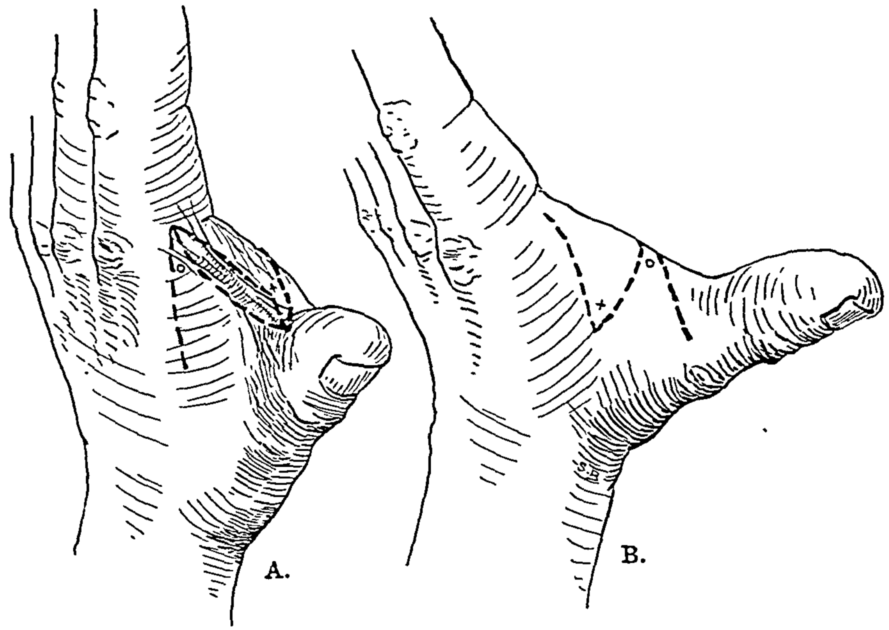


FIG. 9

Showing lines of incision in *B* and transposition of skin flaps in *A* for relieving the flexion contracture of a web.

produces very little disability and will make available five extra muscles in the forearm that may be very valuable through tendon transfer for use in moving the digits.

Stabilization of the wrist in dorsi-extension, whether it be by arthrodesis or through the action of the extensor muscles of the wrist, is absolutely essential for good grip, as otherwise the flexors of the fingers would draw the wrist also into flexion and so lose their strength.

Repair of Tendons in Contractures

Tendons reduced to scar tissue should be excised and replaced by free tendon grafts. Tendons that have been severed for several months must be repaired by tendon grafts, because the distal part of the tendon will have degenerated from disuse and the muscle will have contracted. Tendon transfers are occasionally useful. It is best not to attempt to replace the original number of tendons but instead, by making some tendons do double duty, to reduce the number of moveable parts to a minimum and to furnish sufficient soft mobile tissue between them to allow movement. Frequently it is necessary at a later operation to separate the tendons from each other and from the underlying bone by a free graft of paratenon fat taken from over the triceps tendon.

In repairing the tendons of a finger, usually the sublimis tendon is removed so as to leave but one flexor tendon, as two in a finger would adhere to each other. If, though, the sublimis tendon is cut too short at its insertion, the middle joint of the finger is apt to overextend. If cut too long the

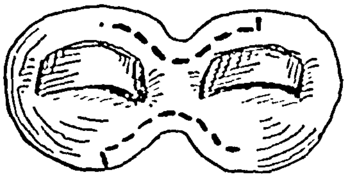


FIG. 10-A

Showing the incorrect operation for webbed fingers. There is not sufficient skin and the linear scar down one finger and up the next is later drawn by contraction from a long V to a short U, reproducing the web and distorting the fingers in rotary and flexion contracture, as shown in Fig. 10-B.

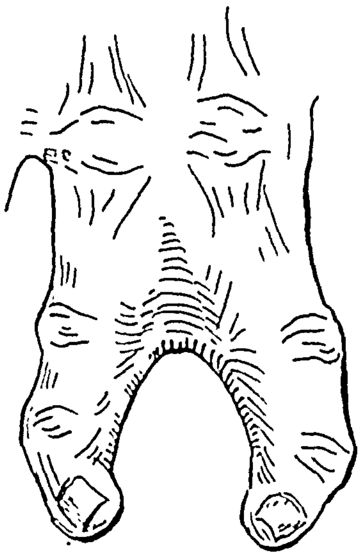


FIG. 10-B

stump of insertion will proliferate and fasten itself to the proximal segment of the finger and draw the middle joint into flexion contracture. Wherever a tendon is cut off, unless in a sheath, its unattached or unsatisfied end should be prevented from attaching itself to the surrounding tissues. This can be done by embedding its end in an adjoining tendon or by anchoring it slack, so it will not, by attaching itself under tension, hinder the movement of other tendons which are drawn by a common muscle. Occasionally after repair of tendons, the mistake is made of splinting the fingers instead of the wrist in flexion. This results in flexion contracture, as the part of each tendon repaired will attach itself to the tissues too far proximal in the limb.

Fractured phalanges and metacarpals cause much disability by holding the tendons in callus, thus causing flexion contracture of the fingers. This can usually be relieved by freeing the tendon and placing a graft of triceps paratenon between it and the bone.

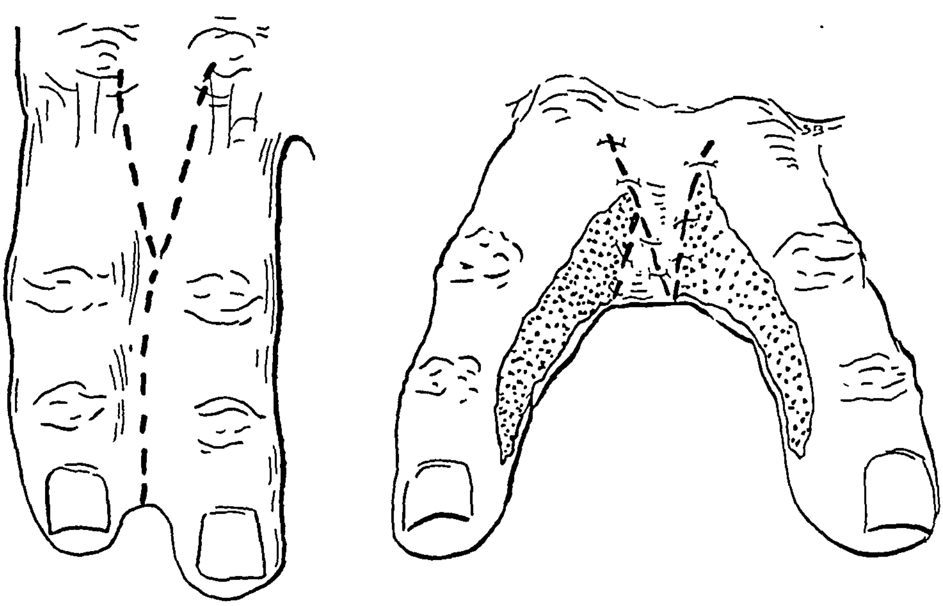


FIG. 11

Correct method of relieving a contracture between two digits or webbed fingers. The pointed skin flaps, sutured across the cleft, establish the depth of the cleft. The denuded sides of the fingers are covered by Thiersch skin grafts.

Plastic Repair of the Skin in Flexion Contractures

Injuries of limbs involve all of the tissues of the limb. We should, therefore, not specialize too closely and we must in justice to the patient be prepared to repair all of the tissues in the limb. Plastic and peripheral nerve surgery are essential.

In flexion contractures the area of skin over the contracture is too small. There is a defect of skin the size of which can be estimated by picturing in the imagination the hand in the extreme opposite position to the contracture. The minimum defect, for instance, in a strongly contracted wrist is three inches in diameter. It is usually much more, because the scar to be excised may be extensive, and also, after all scar is excised and the skin edges undermined, the surrounding skin under excess tension will contract to normal skin tension, thus causing the wound to gap more widely.

Liberation of the deep structures, by substituting for all cicatricial skin good loose, pliable skin, is essential and will greatly improve the nourishment and use of the limb.

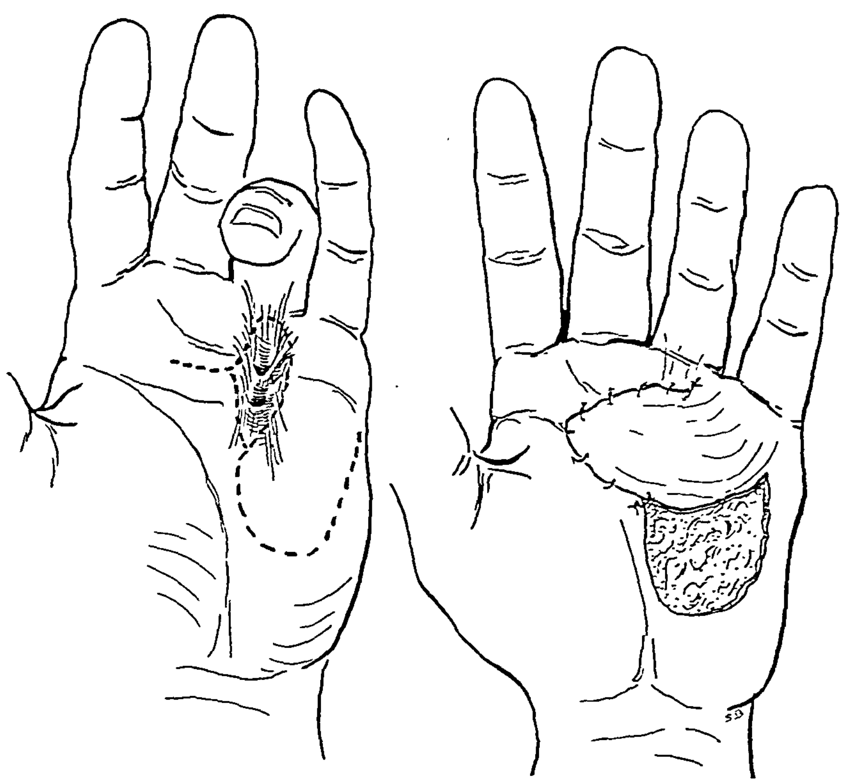


FIG. 12

Wherever there is a line of contracture, a flap of good skin may be swung across it, as a substitute for the cicatricial skin, thus breaking the line of tension. Dotted line indicates incision. The denuded area is closed by Thiersch grafting. Principle is of wide application, but example is of case of Dupuytren's contracture.

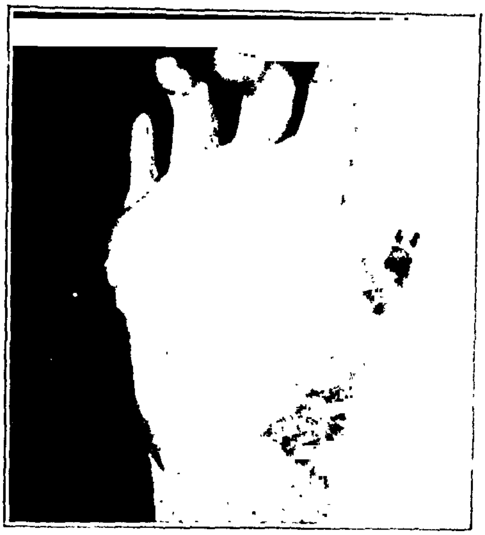


FIG. 13-A

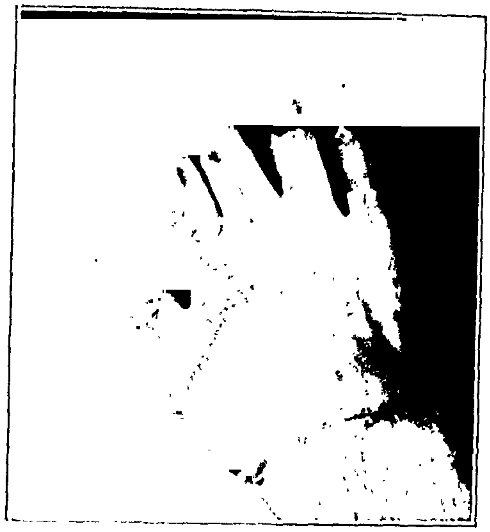


FIG. 13-B

FIG. 13-C

FIG. 13-D

FIG. 13-E

I.W. The hand was crippled from a severe burn from an acetylene blow torch. The thumb was so adherent to the hand by cicatricial contracture that it was useless, as shown in Figs. 13-A and 13-B.

A deep cleft was made between the thumb and the hand. A flap of skin from the dorsum was used to cover the thumb and to establish the depth of the cleft, and the denuded area on the hand was covered by a whole thickness of skin graft. At the same time, by a tendon graft from the palmaris longus of the other arm, a pulley operation was done (as described in a former publication), so that the flexor ulnaris muscle would furnish power of opposition to the thumb as the thenar muscles had been destroyed. A useful, movable, and opposable thumb was the result, as shown in Figs. 13-C, 13-D and 13-E.

FIG. 14-A

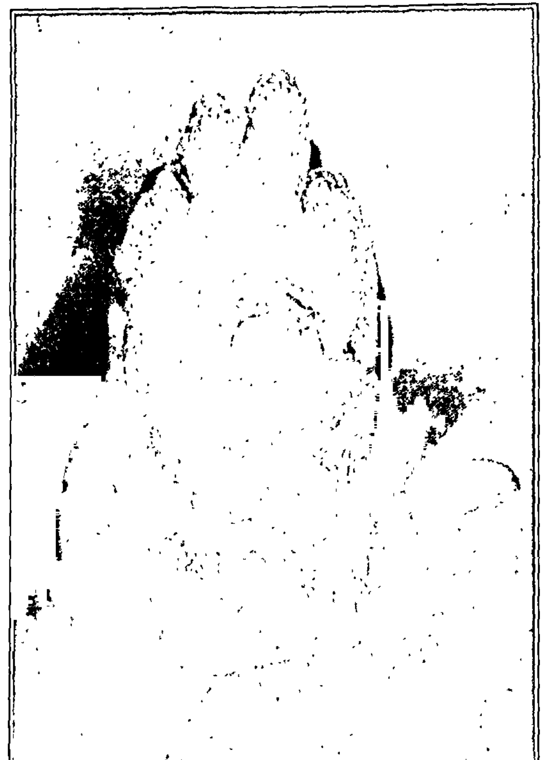


FIG. 14-B

FIG. 14-C

A.M. The volar aspect of fingers and palm were destroyed by the hot rollers of a laundry mangle, resulting in flexion contracture uniting the fingers to the palm, as shown in Fig. 14-A.

Fingers were freed by scalpel, partially extended and temporarily covered by Thiersch skin grafts. Then, by slow traction, they were gradually extended. Median volar incisions were made the length of each finger and the skin was peeled back and sutured to that of each adjoining finger, everting the edges dorsally so that a continuous raw volar surface from index to little finger was produced. A pedicled skin graft from the abdomen was applied to the volar aspect of palm and digits as a whole, as shown in Fig. 14-B, and later the interdigital clefts were cut and the skin was made to cover each individual digit, as shown in Fig. 14-C.

atrophic from poor nourishment. Even the skin suffers from insufficient nourishment and becomes dotted with eczema and ulceration. In such a case, if long longitudinal cuts are made through skin and deep fascia, allowing the limb to expand and the muscles to bulge, and these are closed in at once by a Thiersch skin graft, the whole limb will improve in nourishment and function. Later pedicled skin grafts can be inserted to relieve all lines of tension.

Where fingers are completely flexed and grown to the palm, the cicatrix can be cut through with a knife and the fingers partially extended. By closing in the raw surfaces by Thiersch grafts, gradual extension can be applied, drawing out the nerves and other tissues until the tubular pedicled skin graft can be used to permanently cover them.

Function and importance of flexion creases in the hand to allow movement of joints were mentioned above. It is a mistake to ever cross these at right angles by incisions, as the intermittent tension on the scar results in keloid and contracture. Such a single line of cicatricial contracture can usually be relieved by excision followed by a zigzag plastic. In this the line scar is changed to a zigzag, so that the angulation prevents tension.

Another method is to sever the scar transversely and to swing a skin flap from the adjoining skin into the gap, so as to break the line of tension. The defect left by removing the skin flap is then covered in by Thiersch grafting. This method is particularly useful in correcting Dupuytren's contracture. The skin of the palm will not stretch. The flap is taken from the ulnar aspect of the hand where in the palm there is but little movement and where a Thiersch graft will not be troublesome.

Webs between fingers or thumb can readily be relieved by a zigzag plastic. If the web is deep it is necessary to establish the depth of the cleft by placing a narrow skin flap across the bottom of the cleft. The sides of the fingers may then be Thiersch grafted. Unless this cleft-determining flap is used, the V-shaped scar down one finger and up the next will contract and reproduce the web.

In plastic work certain principles are essential. Hematoma should be avoided by hemostasis, brief tube drainage, and gentle prolonged pressure. For accurate healing, immobilization is necessary and avoidance of any raw area. Overstretching of skin results in necrosis. Skin flaps should be ample in size and with broad bases for good circulation. Skin should be undermined widely enough to prevent tension. In plastic work we should be liberal and radical as tension is fatal.

SYMPATHETIC GANGLIONECTOMY AND TRUNK RESECTION IN ARTHRITIS: INDICATIONS AND RESULTS*

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Sympathetic ganglionectomy and trunk resection result in interruption of vasomotor fibers and improved circulation. Therefore, we have employed this surgical procedure in a small group of cases of chronic arthritis in which there were vasospastic phenomena. In one portion of this group, the arthritic changes were the direct result of the vascular disturbance: for instance, the sclerodactylia in acral scleroderma, Raynaud's disease, and thrombo-angiitis obliterans in which there was spasm of the collateral arteries. These conditions have been checked in their progress, and improved by sympathetic ganglionectomy and trunk resection, but results in this type of case are not presented in this paper.

This study concerns a second portion of this group,—namely, a group of patients who suffer from cold, clammy, pale, or cyanotic extremities preceding or accompanying the arthritic changes. In our study, we investigated the condition of patients who continued to have periarticular arthritis in spite of the usually accepted forms of treatment. We knew that sympathetic ganglionectomy and trunk resection result in improved circulation, and that similar effects are obtained by application of heat; consequently, we wished to judge the results of the operative method in the light of the known results of the older method. It was obvious that operations which would affect the vascular system would not bring about change in the condition of joints that had undergone destruction or ankylosis, but it was hoped that the improved blood supply would alter the metabolism and the course of the disease. Therefore, we wished, in this study, to establish indications for sympathetic ganglionectomy and trunk resection.

In presenting the matter under consideration to a body such as this, it seems unnecessary to present a classification of arthritis, but to provide a proper background for our work we offer for your consideration the classification arranged by Hench, which, at present, is used at The Mayo Clinic. This classification is based on presumptive etiology and contains five main divisions of arthritis: (1) infectious, (2) traumatic, (3) senescent, (4) gouty, and (5) that which represents secondary arthropathy.

*Read before the American Orthopaedic Association, Memphis, Tennessee, April 18, 1931.

1. Infectious arthritis
   Known to be of a specific infectious type, *for example:*
      Tuberculous
      Gonorrheal
      Pneumococcic
      Typhoid
      Syphilitic (spirochetal, not arthropathy)
      Staphylococcic (septic)
   Probably of a specific infectious type (with toxins)
      Rheumatic fever (streptococci or their toxins)
      Arthritis with *amoebic colitis* (*amoebic or secondary* streptococci or their toxins)—rare
      With ulcerative colitis (secondary streptococci or their *toxins*)—*rare*
      With certain skin diseases (especially psoriasis)
   Non-specific (chronic infectious type); streptococcic
      Articular non-specific infectious arthritis
      Non-articular localization (myositis, fibrositis, lumbago)
2. Traumatic arthritis
      Extrinsic trauma (generally acute): (1) articular (traumatic, baseball fingers), and (2) non-articular (nun's knees and housemaid's knees, sprains, strains)
      Intrinsic trauma (generally chronic): postural arthritis, static arthritis of obesity
3. Senescent arthritis
   Chief sites:
      Fingers (Heberden's nodes)
      Hips (morbus coxae senilis)
      Hypertrophic spine of the elderly; cervical frequently, lumbar most common
      Knees (often in combination with static arthritis of obesity)
4. Gouty arthritis
      Acute (*recurring with complete remissions*)
      Chronic (*progressive with residual deformity*)
5. Arthropathy
      Secondary to lesions of the central nervous system (syringomyelia, Charcot's disease)
      Secondary to certain pulmonary conditions (pulmonary osteo-arthropathy)

Sympathetic ganglionectomy and trunk resection have been confined to the non-specific chronic infectious type of arthritis which includes atrophic, proliferative, rheumatoid, and periarticular arthritis. It has not been used in osteo-arthritis, hypertrophic, or degenerative arthritis.

As years go by diseases change in character, and some of them even almost drop out of sight, due to vigorous warfare against them, or to a not altogether explicable decline. Certainly the number of cases of acute rheumatic fever that was encountered twenty-five years ago is not seen today. Although it has not been mentioned in particular, it seems certain that the atrophic (rheumatoid, proliferative, synovial) type of arthritis seen generally in young females in early adult life is also on the wane. It is to this type that the surgical procedure under consideration especially applies. However, even in this group, certain distinct limitations must be set. Therefore, it is evident that there are only a very few out of the vast army of patients with arthritis, who throng the out-patient departments and clinics of the country searching for relief, who should be considered suitable

for this somewhat formidable surgical procedure. This will be considered more fully when selection of cases is considered. Needless to say, what we all recognize as proper conservative treatment should be used in the majority of cases before resort is had to the operation. However, in the type of case that is to be more fully described later in this paper, in which satisfactory results have been obtained, it seems to us that persistence in conservative measures, over a long period, is not only useless, but that the delay may be costly; movement of joints may be permanently restricted, due to pathologic changes in the surfaces of the joint and in the capsule. The general health must be kept at the highest possible point, all possible foci of infection must be removed, the affected parts must be treated by recognized orthopaedic and physiotherapeutic aims and methods,—such as prevention of deformities, application of heat, and so forth. Time need not be consumed here with a list of these various methods.

INDICATIONS FOR OPERATION

In order to produce vasodilatation and to increase circulation to the extremities, it is necessary to interrupt vasomotor fibers completely. Vasomotor impulses, it is supposed, originate in a subthalamic region in the brain, and follow neurones in the vicinity of the pyramidal tracts, to communicate with cells in the lateral portion of the anterior horn of the cord. From there, they are carried over white rami communicantes to the first synaptic connections in the chain of sympathetic ganglia, where they are redistributed as gray rami or postganglionic fibers. Intermingled with the vasomotor fibers are sympathetic fibers, which supply pilomotor muscles and sweat glands; thus, any surgical procedure that completely interrupts the vasomotor fibers to the arteries of the extremities will produce loss of the pilomotor reflex and cessation of sweating.

In the early work, Jaboulay and Leriche attempted to bring about vasodilatation by periarterial sympathectomy, believing that innervation was centrifugal; that is, that the fibers to the arteries followed the trunk of the vessels. Later, they suggested that the innervation probably was centripetal, operating reflexly by afferent fibers following the artery centrally. However, the investigative work of Kramer, Todd, and Potts demonstrated that vasomotor innervation of the arteries corresponded with the musculocutaneous distribution of the spinal nerve. This explained why periarterial sympathectomy failed to produce permanent vasodilatation, since the operation did not include all of the fibers to the arteries.

Royle, in attempting to relieve spastic paralysis, introduced the operation known as ramisection, a procedure which was much more effective in interrupting postganglionic rami than was periarterial sympathectomy, but which still was insufficient to interrupt completely all of the rami to an extremity, since the distribution of gray rami to the spinal nerves is not constant, and often rami are found to enter the lumbosacral nerves at some distance from the corresponding lumbar ganglion. Therefore, in developing a procedure to interrupt thoroughly these vasomotor fibers which carry

vasoconstrictor impulses to the arteries, it was necessary to bear in mind the general course of that distribution. All vasoconstrictor impulses leave the spinal cord by way of preganglionic white rami, opposite the twelve pairs of thoracic nerves and the first and second pairs of lumbar nerves. Vasomotor impulses carried upward, above the first thoracic ganglion, pass over postganglionic fibers to the cervical ganglion, to be distributed to the cervical nerves and arteries of the head, neck, and extremities. The impulses carried below the second lumbar ganglion pass over postganglionic fibers and through the lumbosacral chain of sympathetic ganglia.

In the light of our clinical investigation and experience in the treatment of peripheral vascular diseases—such as Raynaud's disease, thromboangiitis obliterans with vasomotor spasm in the collateral arteries, and the acral type of scleroderma—we have been convinced that permanent vasodilatation can be accomplished by thoroughly interrupting vasomotor fibers to the arteries of the extremities. In the lower extremities, this is accomplished by performing bilateral lumbar ganglionectomy and trunk resection, including the second, third, and fourth lumbar ganglia, and the intervening trunk on each side. If the surgeon were positive that he had divided the sympathetic trunk and all stray rami below the second lumbar ganglion, it would be unnecessary to remove the lumbar ganglion and trunk, but since serious sequelae do not arise from the procedure employed, we believe it is better to err on the side of safety, in removing more of the ganglionic trunks than necessary, than to leave stray fibers and fail to produce complete vasodilatation. The procedure employed in producing vasodilatation in the arteries of the upper extremities consists in resecting the upper portion of the thoracic trunk, with complete removal of the lower cervical and first thoracic ganglia. In order to assure against ascending, stray, gray rami entering the brachial plexus, thorough dissection is made of the lower trunk of the brachial plexus, and all communicating rami or nerve branches to the lower cervical and first thoracic nerves are interrupted. Any stray fibers that are mesial to the thoracic trunk are likewise interrupted. The thoracic procedure has not been so universally successful as lumbar ganglionectomy. In the occasional case, small sweating areas on the hand or arm have been observed following cervicothoracic ganglionectomy, which means, of course, that in spite of this rather extensive procedure a few fibers were still finding their way to the cervical nerves. It is possible that these may ascend through the cardiac plexus.

CLINICAL APPLICATION

Following the results of sympathetic ganglionectomy and trunk resection in Raynaud's disease, Rowntree, in collaboration with Hench, suggested that lumbar ganglionectomy and trunk resection, as employed by Adson, be tried as an experiment in a case of periarticular arthritis of the chronic type. This case and others have been reported by Rowntree and Adson. The arthritis in the case mentioned involved not only the feet, ankles, and

knees, but also the hands, wrists, elbows, and shoulders. Cervicothoracic ganglionectomy by the posterior approach had not been developed at that time, but lumbar ganglionectomy was advised and employed with satisfactory results. The first patient was operated on in June, 1926. In addition to rheumatoid, chronic, atrophic, arthritic symptoms, she presented distinct vasomotor disturbance, complaining of cold, clammy, pale, and occasionally cyanotic extremities. The vasomotor symptoms were relieved immediately by sympathetic ganglionectomy. The skin over the feet and legs became warm, dry, and pink; the pain subsided gradually; the swelling became reduced; the muscles again became fusiform, and the range of motion and the function improved. This experience led to the search for similar cases. It was apparent that this group was rather small when compared with the large number of patients with arthritis who came to the clinic; often ankylosis and destruction of one or more joints had taken place by the time the patient arrived for treatment. It was obvious that improvement in circulation would not alter the ankylosis, but the procedure was employed in some of the extreme cases for its influence in checking the arthritic process or relieving pain in the more advanced cases.

In view of our experience in the treatment of peripheral vascular disease, we applied, in the selection of cases, the same vascular index that we already knew, limiting our selection to patients with non-destructive periarticular changes. In all of these cases the disease was of the chronic type, and the patients previously had received the usual forms of treatment, consisting of eradication of foci of infection, dietary measures, and physiotherapy, with only temporary relief from application of heat.

VASCULAR STUDIES

The vascular studies employed were those outlined by Brown for selection of operative cases of Raynaud's disease and other peripheral vascular diseases. The study was based on changes in cutaneous temperature resulting from administration of foreign protein. It had been known, for some time, that administration of protein in the form of triple typhoid vaccine produced increased cutaneous temperatures in the regions of distribution of non-occluded arteries; the increases were several degrees higher than the increase in mouth temperature. These differences in temperature were the result of inhibition of vasomotor responses by the heat-regulating apparatus, in order to permit more blood to flow to the surface and thus to lower the body temperature, which had risen because of the increased metabolism induced by administration of foreign protein. Brown utilized this principle in developing an index for determining the degree of vascular spasm by measuring the temperature of the mouth and of the skin, before and during the height of the fever. This was accomplished by taking the mouth temperature with a clinical centigrade thermometer, and the temperature of the skin by the electrothermocouple, also graduated in degrees centigrade. Inasmuch as the changes in temperature of the skin of the hands and feet were dependent on patent and elastic arteries and arterioles, Brown

stated that unless the increase in temperature of the skin was two or more times the increase in oral temperature, little was to be accomplished by sympathetic ganglionectomy and trunk resection. This arbitrary rule has been verified many times by postoperative results. It has been of great value in selecting patients for operation. We have found that it offers material assistance in the proper selection of patients with arthritis for sympathetic ganglionectomy. However, it is not infallible, and there have been a few patients with a high vascular index who failed to respond to sympathetic ganglionectomy and trunk resection. It is not safe always to infer that increased cutaneous temperature is going to result in increased circulation to the joints, for it is possible to have associated thrombosis of arterioles in the vicinity of the joints, just as thrombotic processes and vasomotor spasm are found in the group of patients with thrombo-angiitis obliterans.

IMMEDIATE EFFECTS OF OPERATION

Immediately following operation, the skin over the extremities becomes warm, pink, and dry, giving evidence of the vasomotor fibers having been interrupted, as well as those leading to the sweat glands. For five or six days the skin remains flushed; then it subsides to normal color, but if examination is made of the capillary loops after that period, and if their condition is compared with that before operation, it will be observed that the flow of blood, as indicated by movement of the corpuscles, has been distinctly increased. The pain and swelling become gradually less, and continue to decrease while the patient is in bed, at rest; on movement of the joints or use of the extremity, the symptoms may temporarily reappear, but subside gradually. Very often, patients overdo during their convalescence, because they feel so comfortable when at rest, and are prone to become discouraged in the first six months following operation. To obviate this feature, Rowntree urged graduated light exercise and physiotherapy, to avoid undue trauma during this period of restoration. Some patients do not experience as much discomfort as others, and progress slowly from the onset, but the usual course is for a patient to experience marked relief immediately following operation, then for pain and soreness partially to return for three or four months, and finally for gradual and permanent recovery from pain, tenderness, and swelling of the extremities to supervene. The mobility and the return of function continued parallel with the reduction in pain and swelling and the development of muscular function.

OPERATIVE SEQUELAE

To date, in a series of forty-one patients operated on, there has not been a death. None of the patients has complained of a sensation of excessive heat from increased circulation. Dryness of the skin persists, but apparently fails to be an annoyance. In case it should be annoying, daily application of lanolin, or cocoanut oil, would relieve any itching sensations that might arise. In lumbar ganglionectomy and trunk resection some of the presacral fibers are sectioned; hence the impulses to the internal sphinc-

ters of the bladder and rectum, and the inhibitory impulses to the detrusor muscle of the bladder and sigmoid have been reduced, but not to the extent of giving rise to discomfort. As a matter of fact, sectioning of the presacral fibers has been performed to relieve cord bladder and megacolon. The Horner's syndrome, which accompanies cervicothoracic sympathetic ganglionectomy and trunk resection, is neither conspicuous nor troublesome, if equal on both sides. The unilateral Horner's syndrome is most disfiguring, since the contracted pupil and the dropping lid are obvious to the casual observer. Accompanying the ocular phenomena is dilatation of the retinal arteries and veins. These phenomena indicate that vasomotor fibers have been sectioned, and that the arteries and veins actually have been dilated. According to Wagener, who has made preoperative and postoperative measurements, the vessels increase in diameter from a third to a half their preoperative size. He stated, also, that repeated examination of these patients shows that the vasodilatation persists. Muscular pains develop frequently following the sympathetic operation. They appear to become aggravated by massage and passive motion and are described by the patient as "aching pain", and disappear gradually as the muscle returns to normal size and takes on its normal function. The explanation of this phenomenon has not been determined definitely, but we believe it to be due, probably, to engorgement with blood and stretching of the muscle fibers during the regenerative stage. In one case, brachial symptoms, weakness, and paraesthesia developed during operation as the result of pressure while the patient was in a Trendelenburg position. Infections of wounds have occurred, but are no more frequent than in laparotomy or thoracic operations generally. Postoperative ileus likewise has occurred following lumbar ganglionectomy, but again is no more frequent than is observed in extensive laparotomy.

Tables I and II contain data on the types of cases in which operation was performed, and on the results obtained. Group 1 represents the cases in which the disease was most advanced, and in which there were numerous ankylosed joints in which sympathectomy is of no value. Group 2 repre-

TABLE I

TYPES OF CASES IN WHICH OPERATION WAS PERFORMED

Group	Cases*	General results	Average			
			Age at onset, years	Duration of symptoms, months	Vascular index (G. E. Brown)	Increase in cutaneous temperature, degrees C
1	6	Failure	28	92	6.9	9
2	11	Slight (30 per cent.) improvement	29	76	4.4	7
3	20	Marked (70 per cent.) improvement	21	58	4.9	7.6

*In four of the forty-one cases studied, operations were performed too recently to be included in the table; the patients were still in the hospital at the time this paper was written.

TABLE II

RESULTS OF SYMPATHETIC GANGLIONECTOMY AND TRUNK RESECTION FOR CHRONIC ARTHRITIS (FAILURES OMITTED)

Average degree of:	Group 2* (11 cases) Slight improvement	Group 3** (10 cases) Marked improvement
General improvement, per cent.	20 to 30	70
Relief of pain, per cent.	34	75
Reduction in swelling, per cent.	32	67
Increase in motion, per cent.	17	64
Decrease in deformity, per cent.	8	54
Improvement in function, per cent.	7	70
Improvement in walking, per cent.	11	70
Degree of ability to carry on regular work, per cent.	..	74

*Arthritis progressed, in extremities for condition of which operation was not done, in five cases and remained stationary in three, and did not develop in three.

**Arthritis progressed, in extremities for condition of which operation was not done, in six cases, remained stationary in two, and improved in two.

sents the border-line cases, in which sympathetic ganglionectomy and trunk resection may be justified in the hope of reducing the pain and checking the disease. Group 3 represents the cases in which sympathetic ganglionectomy and trunk resection has produced satisfactory results and is indicated because previous, more conservative treatment has failed. In these cases, the operation affords real relief from symptoms, checking the arthritic process. Some extremely brilliant results were obtained in this group of patients, and to emphasize the clinical picture of the properly selected case a detailed report of one case is included. It illustrates the course of the disease, the types of treatment received, and the results obtained from sympathetic ganglionectomy and trunk resection. The report was written by the patient April 1, 1931. She was first admitted to The Mayo Clinic, September 21, 1925, at the age of twenty years, complaining of diffuse chronic arthritis.

REPORT OF A CASE

"When I was about fifteen years of age, I began to have aching pains in my feet. At first these pains occurred whenever I walked, but later were present most of the time. The first doctor I consulted treated me for fallen arches and weak ankles and had special shoes made for me, which gave no relief. The wrists then began to swell and became painful. The swelling disappeared but stiffness and pain remained. During this period of months I consulted numerous doctors and tried various treatments without improvement. I also lost considerable weight and became exhausted and fatigued on the slightest exertion. My tonsils were removed and supposedly infected teeth were extracted. I was ordered to bed and given diets rich in cream and butter, and later tried a fruit diet. I received electric treatment and baking treatment and massage, with little or no value. I then consulted another physician who prescribed quantities of drugs which did appear temporarily to improve my condition to such an extent that I was able to take on college work. While the arthritis seemed to be temporarily checked, at times it was very

troublesome. It had spread to all my joints except those of the spine. My fingers, wrists, and elbows were stiff and motion had been distinctly impaired.

"After continuing college interruptedly for three years, I became worse and had to discontinue school. It was then that I consulted the staff of The Mayo Clinic at St. Mary's Hospital where I was given examination after examination in the hope of locating some source of infection. None was found. I was given physiotherapy, daily, and took typhoid vaccine weekly in regular courses of five or six treatments. These treatments at first appeared to help me, but again failed and my symptoms continued. About a year later I did improve sufficiently so that I was able to continue my college work, graduate, and began to teach, when I developed symptoms of chronic appendicitis. This I was told was the probable source of my infection and therefore had an appendectomy. Following this I did improve for a time and began to teach again, when my arthritic symptoms flared up and aggravated the numerous painful joints.

"Again I consulted The Mayo Clinic staff and was placed on various diets, rest, and physiotherapy. I now found that I was tired all the time and that it was almost impossible for me to bend or move at all. It was following this attack that special vascular studies were made and sympathectomy was discussed. My hands and feet had always perspired a great deal and were always cold and clammy, but before accepting the operation I was advised to try some colon irrigations, which were of no value. My knees, hands, wrists, elbows, and neck were then treated with x-rays for six months, but in spite of this my symptoms grew worse and I was glad to try any sort of operation with the hope of getting some relief, and submitted to cervicothoracic sympathectomy by Dr. Adson December 20, 1929. Immediately following the operation, my hands became warm and dry, and to my surprise the pain in my arms and hands had gone. Since then, during the sixteen months' period, the pain has not returned and the movement of my hands and arms has increased so that I am able to use them and I have been able to carry on my school work. The muscles of the hands and arms have increased in size and strength, but the deformity of the joints and the ulnar deflection have not changed.

"Five months following the operation for the upper extremities, I submitted to lumbar sympathectomy and have received equally good results. The skin over my feet and legs has become warm and dry; the swelling and pain have disappeared, and only twice have I experienced any pain in my knees. I returned to my position of teaching last September and have continued to teach every day. My general physical health has improved also, so that at present no one would know that I had ever been ill."

SUMMARY

It is apparent that there is a group of cases of chronic arthritis in which vasospastic phenomena are seen and are responsible for or aggravate the arthritic symptoms. Sympathetic ganglionectomy and trunk resection offer additional aid in the treatment of these patients, but extreme care should be exercised in the selection of cases. Sympathetic ganglionectomy and trunk resection is indicated for young persons, who have vasomotor phenomena, such as cold, wet, pale, or cyanotic extremities, but whose arteries are patent, elastic, and not occluded. The operation is not indicated in advanced cases, in which there is marked ankylosis; neither is it indicated when the infectious process is still present. The operation affords the greatest amount of relief in the smaller joints of the extremities,—fingers, hands, wrists, toes, feet and ankles. When there is involvement of the larger joints—such as the knees, hips, shoulders, and spinal column—little is accomplished either in checking the disease or in ameliorating the symptoms.

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TREATMENT OF VASCULAR DISEASES OF THE EXTREMITIES BY SYMPATHECTOMY*

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RAYNAUD'S DISEASE

Claude Bernard[1] demonstrated the fact that the vasoconstrictors, controlling the vessels of the extremities, arose in the sympathetic system. His work was, of course, on lower animals and done for experimental purposes.

Raynaud[2] published his first papers in 1862, and writes of his first case as local syncope of the most simple form. He describes this as a momentary absence of local circulation. In his Case 3 he describes the condition as due to a spasmodic state of the radial and ulnar arteries. Autopsy findings of a patient, who for years had had typical symptoms of local syncope, revealed no abnormalities of the arteries. Raynaud was aware of the experiments that had been done wherein the fact was established that section of the sympathetic system raised the surface temperature of the part. He listened to heated discussions as to the explanation of the phenomenon of the increase in local heat.

He, therefore, finally considered that local syncope was due to spasm of the arterioles and that there was no pathological change to be found in the vessel. Ergot did not produce the condition. The treatment he recommended had nothing unusual or of a specific nature, except perhaps the belief that galvanism was of distinct value. It was applied over the spine. Strangely enough, Raynaud does not note or remark upon an outstanding symptom,—*viz.*, sweating and moisture of the extremity.

In the second publication by Raynaud he was able, in a typical case of disease, to study changes in the eyes, and he found that, during an acute attack, at the time the extremities were cyanotic, there were definite changes in vision that alternated with the attacks,—spasm in the retinal arteries together with an abnormal pulsation of the veins. Hemiplegias were noted in cases of this type, but surely they must be of a transient nature to be included in this group,—the product of vasospasm.

Raynaud's disease is therefore the ideal condition for treatment by sympathectomy. We now know by clinical experience, as well as by animal experiments, that one may with impunity interfere with sections of the ganglionic system without dire results accruing to the patient (Cannon[3]). That the present phase of surgery of the sympathetic nervous system owes its inception to the work of Royle[4] is obvious. In his first case of lumbar ramisection he observed changes in the temperature of the limb on the same

*Presented at the Annual Meeting of the American Orthopaedic Association, Memphis, Tennessee, April 18, 1931.

side as the operation. These changes were assumed to be due to increased blood supply. Other factors enter into the question of increase in temperature. Instruments of precision are now to be had which will give accurate surface temperature readings. Surface temperature is dependent also upon the surrounding air temperature, in that cold air will stimulate the vasoconstrictors in the normal limb, leaving the treated limb with its peak load of blood in the vessels. The normal limb will, therefore, be much colder than the other. The difference may be seven or eight degrees centigrade.

Another factor of decided moment in the explanation of temperature readings is the change in the moisture of the skin of the extremity. The sweat glands are supplied by the sympathetic nerves and as these are overactive in Raynaud's disease, the extremities are moist and there is consequently a great loss of heat by evaporation. More heat is lost from a moist foot than from a dry one.

Prof. Burton, of the Department of Physics of the University of Toronto, has recently constructed an instrument with which we have been estimating the moisture of skin. It is very accurate apparently and the evaporation records show an extraordinary difference before and after sympathectomy and between limbs that have lost their sympathetic control and those that have maintained it.

To my mind the outstanding objective feature of a limb, following sympathectomy, is the dryness of the skin. Stroking the normal skin and the skin of an involved limb shows a marked difference. This difference is present also at the level of anaesthesia in patients who have spinal anaesthesia. Advanced cases of Raynaud's disease are very rare and the acute phase is apparently a rapidly progressive one.

The following is a description of a typical case of Raynaud's disease.

M.B. White female, twenty-nine years of age.

From the time she was a small child she suffered from cold, clammy hands. When she was twenty-two years of age, her tonsils were removed. She was well and employed as a stenographer and carried on regularly at this occupation. In the summer of 1929 she observed that she was becoming constipated and that she required an aperient daily. In addition, later on, it became necessary to take an enema every other day. She noticed in August 1930, that washing her hands in cold water left them mottled, cold, and numb. On September 28 she wakened to find that her hands, feet, face, and whole body were swollen. She was in bed for a week or so, during which time she suffered from stiffness and pain in her hands and feet. Following this acute phase, she found that the symptoms that involved her hands were more marked. The stiffness became such that she found it difficult to make a fist. The fingers appeared dark and congested, more specially marked in cold. Her fingers were so tender that she found it impossible to type with certain fingers. Medical and palliative treatment had no effect on the condition and she was referred for surgical treatment on December 1, at which time she was complaining bitterly of tenderness, stiffness, and discoloration of the fingers and toes. The fingers showed a marked loss of the pulp at the ends. The hands were clammy and cold, and on the first and second fingers of the right hand were small flat areas which resembled dry gangrene. The left hand showed a similar involvement with the exception of the little finger and the ulnar side of the ring finger. This area appeared normal in color and was not so tender as the other areas. Her radial pulse, while small, was palpable. Her feet were mottled in appearance, having dark red patches, and were cold and moist to the

touch, and she said were stiff and painful. Her general condition was wretched. She suffered almost constantly from headache. Her constipation was marked and resisted treatment. Her metabolic rate was undisturbed; her pulse rate ninety-three, and blood pressure: systolic, ninety-four; diastolic, fifty-two.

On December 4 she was prepared for operation, and an operation used by Adson[5] and originally devised by Henry[6] was performed. Briefly it was as follows: A mid-line incision was made from the tip of the sixth cervical vertebra to the fourth dorsal. Subcutaneous tissue was divided and retracted to the right side. An incision was made through the aponeurosis of the attachment of the rhomboid and trapezius. This incision was carried down through the spinal muscles until the tip of the transverse process of the second dorsal vertebra was felt. The transverse process was cleared subperiosteally of all attachments and a chisel divided it from the vertebra. This being removed, the neck of the second rib was exposed. Periosteal dissection was made of the second rib out as far as the angle. At the angle it was divided with a pair of biting forceps. A sharp instrument was then used to divide the ligaments of the head, and the neck and head were removed. A small opening was made at the internal end of the wound through the periosteum, from which the rib had been removed, and the finger, exploring gently, was able to push downwards and forwards the parietal pleura and the apex of the lung. This was pushed back until there was a cavity about the size of a walnut. Crossing the mesial end of the quadrilateral space was to be seen a cord. On dissection of this one could, without difficulty, identify the second thoracic ganglion with its gray ramus going to the second thoracic nerve and the thoracic cord running upwards to disappear under the first rib. Dividing the thoracic trunk just below the second thoracic ganglion and freeing the ramus from the second thoracic ganglion, it was found that gentle traction brought into view, from under the first rib, the lower extremity of the first thoracic ganglion,—that is the lower part of the stellate ganglion. Gentle dissection with the fingers and the blunt hook mobilized this, so that it could be brought into the quadrilateral opening where the different rami from it were pulled off by blunt dissection and the entire ganglion was visualized as well as the cervical cord going upwards to the middle cervical ganglion. The cord above the stellate ganglion was divided. The same procedure was followed on the opposite side. The wound was closed in the usual fashion, except that the skin was closed with subcutaneous No. 0 catgut stitch.

This operation was selected, because of the possibility of doing both sides through one opening and having the wound in the back, which would be a consideration in the case of a female.

Following the operation her condition was excellent and showed no shock. It was noted by observers that on reaching her ward, her hands were normal in appearance. When she became conscious she stated that her first conscious act was to make a fist, which delighted her inasmuch as she had been unable to do this for a long time previously. Within an hour of her operation her hands were warm and dry and normal in appearance. When she became *compos mentis*, she declared that her pain and stiffness were gone; and for the first time in her life her hands felt warm, dry, and comfortable. She stated that she was conscious of a heaviness to her eyebrows and eyelids. There was no obvious change in the general appearance of her face. Her pupils were inactive to change on pinching of the skin of the neck, but reacted to light and, to a much less degree, to distance. She was not conscious of any further change in the face, eyes, and neck. On December 7 she began to complain of pain in each shoulder girdle and up the back of her neck. This pain was troublesome and she described it as neuritis. It had entirely disappeared on December 12.

The excision of the ganglia in the lower cervical and upper thoracic region had temporarily upset the function of the lumbar ganglia, as for two days following her operation her lower extremities were warm and dry and normal in action. They soon returned to their state prior to the operation.

On December 13 she was again taken to the operating room and a sympathectomy of her lumbar ganglia was done on each side, following the approach described by Royle.

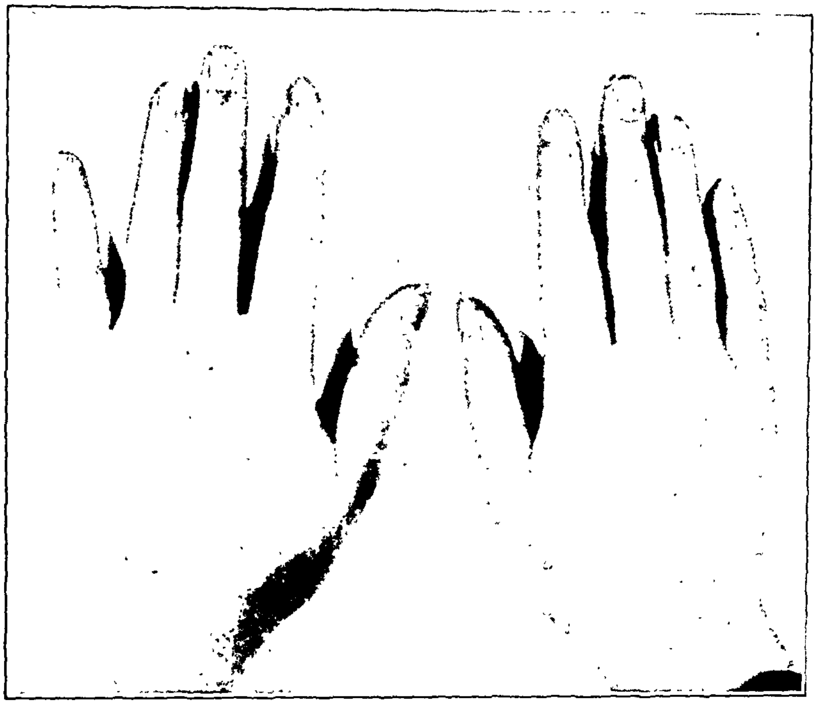

FIG. 1

The hands before operation, showing the congestion and cyanosis of the hands and fingers, especially the tips.

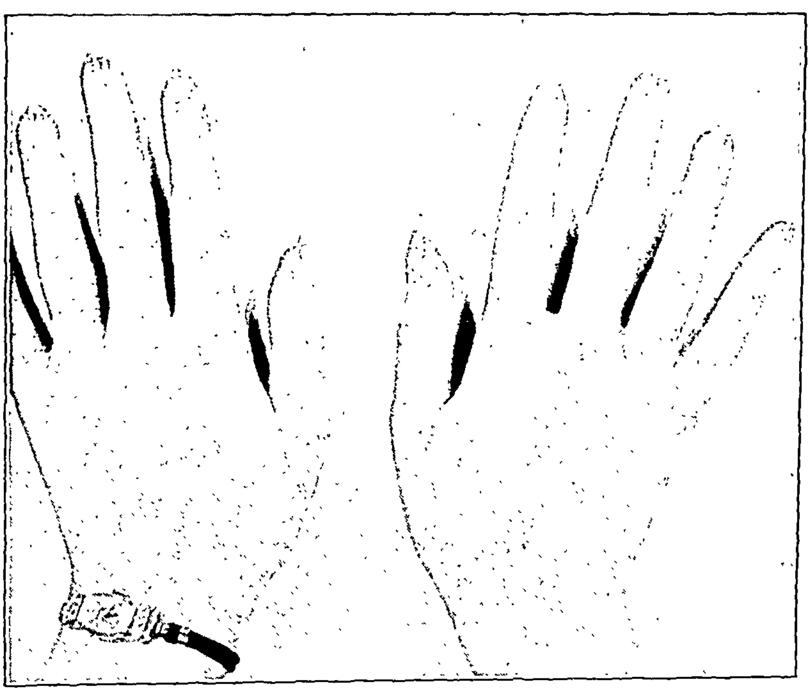

FIG. 2

After operation. Cyanosis is seen to have disappeared and hands are normal in color.

On the return to her ward her feet were found to be normal in color and the warmth increasing. As she became conscious she found that her legs were dry, warm, and comfortable. The temperature reading of her arms and legs was taken before and after operation by an electric apparatus devised by Prof. Burton. The temperature changes were those characteristic of a sympathectomy.

Pathological report of the ganglia excised was as follows:

December 4. Diagnosis: Stellate ganglia with chronic inflammation.

The gross specimen consists of the right and left stellate ganglia, measuring approximately one and five-tenths by one by seven-tenths centimeters. They are grayish-pink in color, rather firm in consistency, and their cut surfaces are of a glistening, compact, whitish appearance.

Microscopically, sections of ganglia show them to be made up of many large ganglion cells supported by neuroglial fibers. Throughout, there is a slight lymphocytic infiltration. This lymphocytic infiltration is more marked in the right ganglia than in the left.

December 15. Diagnosis: Non-medullated nerve and ganglion.

The gross specimen consists of lumbar sympathetic trunk from the right and left sides. They measure approximately the same, being two and five-tenths centimeters in length by four-tenths of a centimeter in thickness. They are grayish-pink in color, soft in consistency, and present two small dilatations along their course.

Microscopically, sections from both sides show them to be made up of non-medullated nerve fibers and ganglion. The ganglion is made up of bundles of nerve fibers interspersed about which are a large number of ganglion cells.

On March 4, 1931, she reported that constipation had entirely disappeared. She takes a small quantity of liquid paraffin daily and this is ample to produce daily movements. The headache she has not had on a single occasion since the operation on December 4, 1930, when the stellate ganglia were removed. Her Horner's syndrome is not obvious objectively and barely subjectively. Electrocardiagram: normal. Blood pressure: systolic, ninety-eight; diastolic, sixty-four. Pulse: seventy-two at rest.

In this case rate response to exercise and response to respiration (sinus arrhythemia) are not altered by break of sympathetic.

DISCUSSION

This patient had suffered from cold hands and feet as long as she could remember. Constipation appeared in the summer of 1929 and became troublesome in the summer of 1930. The fingers were noticed to be mottled after using cold water. An acute phase appeared on September 28, 1930, following which the condition of her extremities became worse, so that when she was seen on December 1, 1930, she had some patches of dry gangrene on the tips of her fingers. Excision of her stellate ganglion on each side, as well as the lumbar ganglia, improved immediately the circulation in the hands and feet so that it appeared more than normal. Subjectively the hands and feet were more comfortable than they had ever been. The function of the sweat glands was so diminished that the limbs were no longer moist but became dry. Our experience in lumbar ganglionectomy would warrant us in definitely stating that this woman's constipation would be absolutely cured, as the subsequent events have proved. She has no focus of chronic infection that we can locate. The whole picture is one of involvement of the sympathetic system and hyperactivity, causing vascular disease and involvement of her smooth muscle control of the intestines.

THROMBO-ANGIITIS OBLITERANS

The pathology underlying this condition is entirely different from Raynaud's disease. Many excellent descriptions of the symptoms and pathology in this condition are available, one of which is "Thrombo-angiitis Obliterans" by Brown, Allen and Mahorner[7]. The disease is one that has been known for centuries but which has been classified comparatively recently (Buerger[8]). The symptoms of this disease are clear-cut, and its diagnosis presents no difficulties, nor is the outcome of the disease dreadful in all cases, as was formerly believed. Some cases have symptoms of a very mild nature over many years. Some have marked symptoms and gangrene of a fairly extensive nature and then have years during which they are free from symptoms. Some observers believe that tobacco is an etological factor, and recently I saw a patient who had had six amputations of fingers, toes, and one leg, who suddenly became free of symptoms when he stopped smoking, a habit to which he had been heavily addicted. After ten years' freedom from symptoms he again resumed his use of tobacco for the period of one month. Symptoms promptly returned, and disappeared with the discontinuance of tobacco.

In spite of the fact that there is a mechanical block of the vessels by proliferation of cells and organization of clot, there is present in clinical cases a large element of vessel spasm, as is amply evidenced by the work of Brown, with his protein test. Temperature increase occurs in spinal anaesthesia and temperature increase and relief of pain and symptoms are produced by infiltration of the lumbar and cervical sympathetics by novocain and alcohol, also by the infiltration of peripheral nerves by anaesthetic as is being done by Morton and Scott.

Some of these methods have been and are being used to determine which cases show a large element of spasm, as such cases are suitable for sympathectomy.

The varying severity of the condition in different cases makes it difficult to apprise any form of treatment. The estimation by a precise method of the element of vasospasm in any particular case is of value, but it is probably true that every case of thrombo-angiitis obliterans has some degree of spasm, and this spasm can be relieved by sympathectomy. Recently a patient recovered pulsation in the dorsalis pedis immediately after operation. If this operation is done empirically the experience will doubtless be that every case will derive some benefit. We have not had a single patient who did not feel greatly improved, following operation. Pain is relieved without exception, wholly, or in part. Temperature of the foot is increased, and local amputations may be undertaken, with impunity. The hope that an ulcer may be cured by this surgical proceeding alone is vain. That sympathectomy may be a factor in arresting the disease is unknown, but that it is of distinct value in a case of threatening gangrene can be answered in the affirmative. I have yet to see a patient who, having had the experience of an operation, did not give favorable evidence.

The worst case of thrombo-angiitis obliterans is evidently the case that has an obvious degree of superficial phlebitis. Cases of this type show a very slight improvement, if any, following sympathectomy.

ARTERIOSCLEROSIS

This condition, like thrombo-angiitis obliterans, is one where there is a definite pathological change in the vessel wall, but unlike thrombo-angiitis obliterans has not the tendency to the formation of an adequate compensatory circulation. It is universally more progressive. In those cases associated with diabetes, the condition is more serious. Sympathectomy in impending gangrene from arteriosclerosis, or in cases where there are the symptoms of ischaemia—such as claudication, numbness, and pain in extremities—has a very definite place and is of decided advantage. A man of seventy with general arteriosclerosis developed symptoms of ischaemia in his legs. His numbness was marked, but the pain in his feet was such that he was bed-ridden and unable to sleep without the aid of morphia. His feet were cold and moist, dorsalis pedis and post-tibial arteries were pulseless on palpation. A double lumbar sympathectomy was performed in September 1930. Following the operation he said his feet were comfortable. They felt warm and dry. These last two features were easy of clinical confirmation. At the present time, six full months after operation, his condition is as follows: He is up and about. He has some numbness persisting. The feet are subjectively and objectively still warm and dry. The post-tibial is palpably pulsating at the left ankle and he has required no drug for pain since his operation.

Our experience with this condition complicated by diabetes is not so happy. We have had no early cases, but in those advanced cases, where gangrene was already present and in a moist or infected form, pain has been diminished but the ulceration has not been cured. One would, however, feel that early interference with the sympathetic trunks would, in combination with insulin, be sufficient to relieve the vasoconstriction in the diseased vessel, and thus increase the blood supply to such an extent that gangrene might be altogether prevented and any early infection might be defeated. It is certain that if no other benefits accrue, the comfort of the patient will be materially increased. It is possible also that, following sympathectomy or associated with it, more conservative amputations may be done.

CONCLUSIONS

1 In Raynaud's disease sympathectomy will relieve the symptoms of the disease and prevent the formation of gangrene.

2. All cases of vascular diseases of the extremities have associated vasospasm in a varying degree. This latter can be relieved by sympathectomy.

3. Sympathectomy leaves no important deleterious effects either in the lumbar or cervicothoracic excisions.

4. Lumbar sympathectomies improve the bowel action.

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ADVANTAGES OF OPERATIVE TREATMENT OF FRACTURES OF THE ELBOW

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Because of the frequency of fracture of the elbow, it is wise to place emphasis on certain special points in regard to the effect of trauma in the treatment, for, because of the importance of the perfect function of this joint, favorable conditions for its cure are most essential. In considering the subject, we have used the term "elbow fracture" in order to place these fractures in a group which includes injury to all the bones of this joint. From a study of the records of the Juárez Hospital, it is found that,

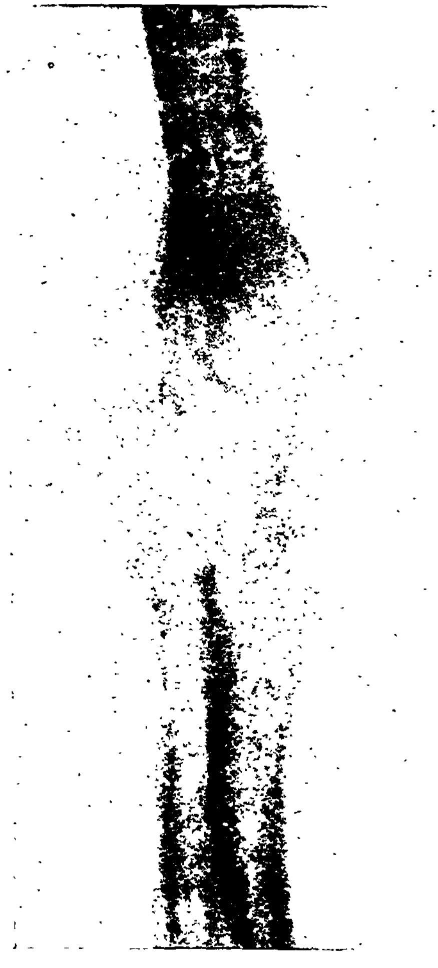

Fig. 1
Case 1. S. L. Fracture of condylar type.

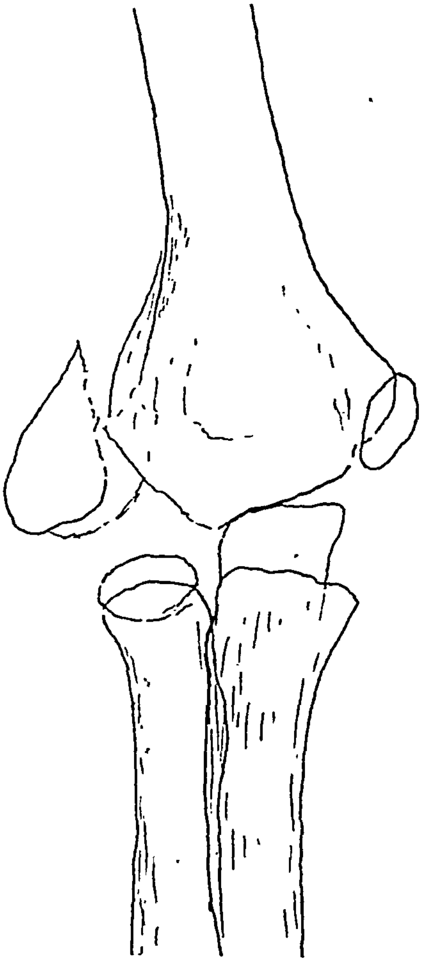

Fig. 2
Tracing of x-ray shown in Fig. 1.

next to fractures of the leg (femur, tibia and fibula) and the clavicle, fractures of the elbow are most frequent. Of the fractures of the elbow, the larger number are fractures of the lower end of the humerus and it frequently occurs that when one of the lower bones is fractured, the other is dislocated. These fractures occur most frequently in children and adolescents, occasionally in adults, and very seldom in older people.

In making an accurate diagnosis, it must be remembered that the muscles play an important rôle and must be considered in differentiating between dislocation, fracture, or contusion. Valuable data can be obtained by careful observation of the appearance, shape, volume, etc., and also of the ecchymosis, which in a fracture is invaluable datum, sufficient in itself, we believe, to furnish evidence of fracture within the joint when it is extensive and appears late and near to the joint, whether it be the shoulder, elbow, knee, or ankle. The use of the x-ray is always necessary.

Especially in elbow-joint fractures, is it necessary to bear in mind the three therapeutic principles in the treatment of fractures: first, the best pos-

FIG. 3
Case 1. S. L. Lateral view.

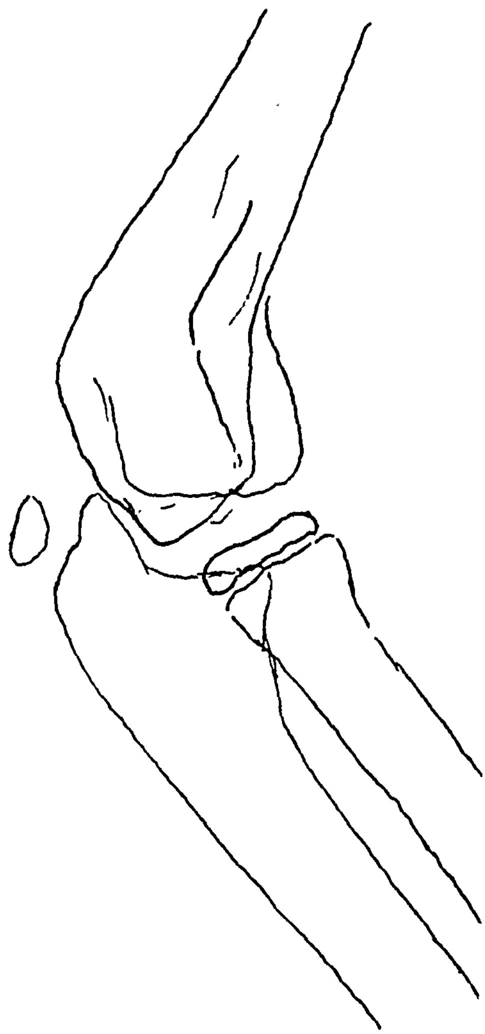

FIG. 4
Tracing of x-ray shown in Fig. 3.

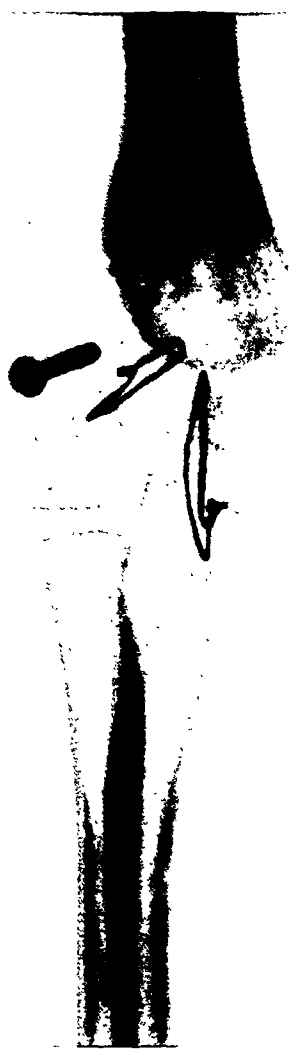

FIG. 5

Case 1. S. L. After operation, showing prostheses consisting of a screw and a wire lap attaching the condylar fragment to the humeral fragment and a second wire lap holding the olecranon in place.

FIG. 6

Tracing of x-ray shown in Fig. 5.

sible coaptation of the fragments; second, the maintenance of the reposition; and, third, the subsequent treatment to restore function. It should be borne in mind particularly that the aim of the treatment of the fracture is to restore as promptly as possible the movement of the joint in its proper alignment, and the development of muscular strength, and, although it was formerly believed that perfect apposition was necessary in all fractures, we are convinced that such is not the *sine qua non* condition. Yet in fractures of the elbow-joint, this is of great importance because of the complicated structure of the joint.

With the elbow joint the main purpose should be to secure the prompt formation of a solid callus, which is firm, but not so large that it will inter-

FIG. 7
Case 1. S. L. After operation; lateral view, showing the parallelism of the projected curves of the joint.

FIG. 8
Tracing of x-ray shown in Fig. 7.

fere with the early motion. Good results in the formation of such callus are obtained in direct proportion to good anatomical replacement, for under these conditions the osteogenetic evolution takes less time and is more uniformly distributed. For this reason it is necessary in this type to obtain the most complete anatomical replacement in order to secure the best functional restoration.

In the period after reduction, the treatment is of importance, for, as is well known, the joint has the peculiarity of producing fibrous exudate which forms large calluses tending to produce adhesions in the joint, with subsequent immobility, as well as muscle atrophy, due to nerve compression. An illustration is cited of the case of a child with internal condylar fracture in which imperfect early treatment had resulted in occlusion of the

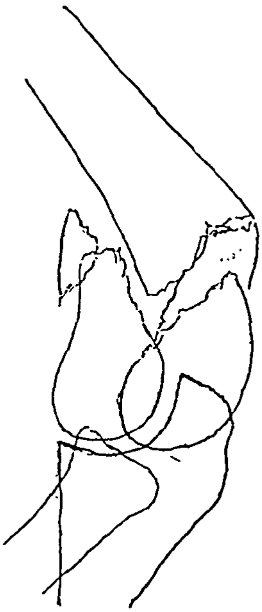

FIG. 9

Case 2. S. E. Tracing of x-ray; lateral view, showing humeral fracture with five different fragments.

FIG. 10

Case 2. S. E. After operation; lateral view. Shows a screw in the lower part of the humerus and a projection of a Y-shaped plate in the upper part. The consolidation callus can be detected toward the anterior part of the humerus.

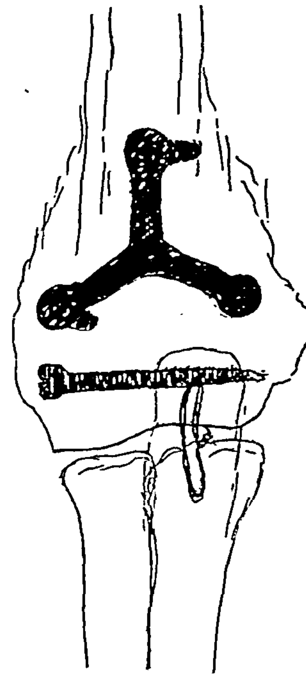

FIG. 11

Case 2. S. E. After operation; anteroposterior view. The joint is free and the callus is situated principally in the upper part of the bone.

cubital nerve during the osteogenetic process, requiring the dissection and separation of the nerve. Later a resection was performed, and finally, a second operation in which an injury to the epiphysis occurred. Even after undergoing massage, electrical treatment, etc., the child was left with an atrophied arm, a short and atrophied forearm, and marked deformity of the fingers and hands.

Our object, then, is to restore the displaced fragments as soon as possible and to hold them so firmly in position that the treatment for the maintenance of mobility may be begun early. This is closely in accordance with the teaching of Dr. Lucas-Championnière who recommended massage and immediate movement for the treatment of fractures.

It is very frequently seen in these complicated fractures that it is quite impossible to insure the complete reposition of the fragments by the indirect or external (non-operative) means, because of the difficulty of coapting the several completely displaced fragments which are again misplaced in manipulation. It is also difficult because of the groups of strong muscles which surround this joint.

It is not the purpose of this paper to compare the two methods, but it can be stated that in the bloodless method there is always the difficulty of keeping the joint immovable for a time long enough to allow the replaced

fragments to form sufficient callus to prevent their displacement when movement of the joint is begun. There is, therefore, the conflict in the treatment between the necessity of immobility in order to obtain coaptation and the use of mobility for the preservation of function.

The advantages of the direct or open method are easily understood when we consider the desirability of the maintenance of the position of the fragments.

First, an anatomical replacement of the bone fragments is possible.

Second, this coaptation is maintained by means of prostheses which may be handled and applied easily and which are sufficient to hold the fragments in position against any ordinary strain of muscle action in this joint, for we have to deal with several small epiphyseal fragments, which may be termed satellites. The means of replacement of the fragments will vary with the case, but *we believe that in cases of complex fractures, as in* the cases here reported, because of the difficulty of reduction of the small fragments and the trauma incident to the attempt, the reposition should be made not only as early as possible, but by the means resulting in the least trauma.

Third, the early restoration of function can be accomplished by this method even before consolidation takes place. The individual fragments are not isolated as before reposition, but, because of maintenance by the prostheses, form a single body.

In this method we strive to obtain the following:

1. Quick, easy, and free access to the articulation.
2. The placing of the prostheses to insure stability of the fragments.
3. The assurance that the prostheses are not so placed as to interfere with the articular surfaces.
4. Maintenance and the return of function.

The method of approach in these cases is through two straight incisions, united by a small curved incision starting at five centimeters from the articular line at the posterior part of the elbow and the superior side of the median line. The incisions are started on the posterior part of the elbow and united at the lower part by a curved incision, which is at the level of the olecranon. The incisions can be made with the arm extended or flexed and should expose the bone. The cubital nerve is isolated and the olecranon severed by a saw, if the patient is an adult, or by a knife, in the case of a child. With resection of the olecranon, free access to the joint is given, and the sectioning of the olecranon has not been found to have any disadvantage in the subsequent healing process. It is united later by a strong wire, and in all cases the consolidation has been complete.

For the prostheses, a screw from three to five centimeters long is valuable for fractures in which the trochlea and condyle are involved. Plates and wire also have been used without disadvantage. As before stated, care must be taken that the prostheses shall not be placed so as to interfere in any way with the articular surfaces. It is never necessary to drain.

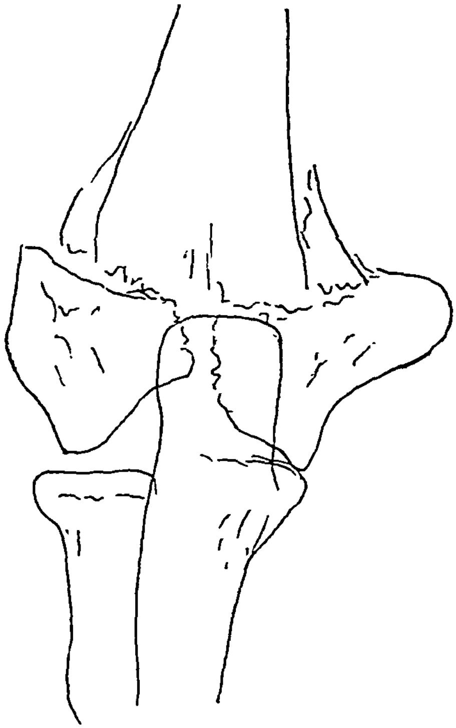

FIG. 12

Case 3. M. C. Tracing of x-ray, showing fracture of the humerus with five fragments.

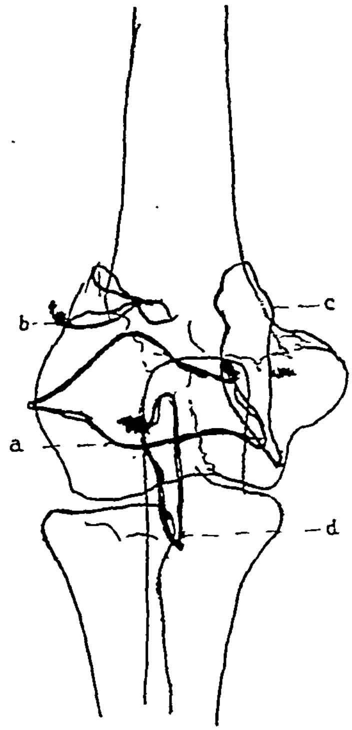

FIG. 13

Shows the use of four wire laps: *a* holding the two inferior fragments together and reconstructing the articular surface; *b* and *c* situated in the upper and lateral parts in order to fix the two upper small fragments to those connected by *a* and the whole to the lower part of the humerus; *d* holding the olecranon in place.

Fixation by plaster is never used because of the firm retention of the fragments by the prostheses, and because of the necessity of early treatment for function. Pasteboard splints are usually used, with the arm in extension, and are sufficient. This position is maintained from five to eight days, after which the splints are removed, and the patient is allowed to keep the arm straight for a few days. Eight days later, motion is begun with subsequent physiotherapy as necessary.

In cases treated by this method, no stiff joints have followed. This compares favorably with the other methods, for one frequently sees ankylosed joints following the closed method of treatment.

The following three cases, a child and two adults, show the results of the operative treatment in different types of fractures:

CASE 1. S.L., aged eight years. Four months previous to his admission to the hospital had fractured the elbow. Upon examination it was found that the fracture had not consolidated, was of the condylar type with separation of the condyle and epicondyle, as shown in Figures 1 and 2. In the lateral view only a lack of parallelism in the projection can be seen with marked limitation of the movements of flexion and extension and painful supination. An open operation, using transverse screw and wire, was followed by physiotherapy. Results are shown in Figures 5, 6, 7, and 8.

Case 2. S.E. Entered hospital in coma with fracture of the base of the skull, and fracture of the right elbow showing five fragments of the humerus. After recovery from fracture of the skull, an operation was performed upon the elbow with local anaesthesia on the brachial plexus. The fragments were held in place with a transverse screw and a Y-shaped metal plate as shown in Figures 9, 10, and 11. End results show strong callus, firm union, and complete function.

Case 3. M.C., a chauffeur. Admitted to hospital with fracture of right elbow fifteen days old, of type sometimes called motorist's fracture, caused by back-fire while cranking a car. The five fragments, irregular in shape, can be seen in Figure 12. An open operation was performed under regional anaesthesia. In this case it was not possible to secure suitable screws so wire was used, binding it several times until firmness was obtained. In spite of the fact that some of the wires were placed intra-articularly instead of intra-osseously, everything possible was done to adapt them to the contour of the surface. Function was restored and the patient is working again as a chauffeur.

These results are given in order to submit the author's impressions of the value of the open method in the treatment of severe fractures of the elbow.

TRAUMATIC DISLOCATION OF THE SHOULDER

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INTRODUCTION

It is usual to describe two main types of dislocation at the shoulder, subspinous or backward, and subcoracoid or forward dislocation.

In the material available to us there are but three cases of subspinous dislocation. These are all bilateral, more or less symmetrical, and undoubtedly not traumatic in origin, but produced by a deformity of the glenoid surface early in foetal life at the stage of preformation of the joint by cartilage. They have already been fully described.[1]

Our concern is with the frankly traumatic type comprised under the general heading of subcoracoid dislocation.

Among the collection of 1826 complete human skeletons in the Hamann Museum of Western Reserve University, twelve examples are presented of recurrent and unreduced dislocations, varying in degree, but all of traumatic origin. This high incidence is probably accounted for by the fact that, in this group, there was rarely much deformity. The patients, therefore, probably never sought surgical attention. In contrast with this, the unreduced dislocations of the shoulder seen by the writer in private practice have all been instances of frank subglenoid dislocation with considerably more deformity than those described in this paper.

SURGICAL CLASSIFICATION

A study of the specimens here recorded has prompted us to formulate the following classification:

A.	Congenital anomaly		Backward dislocation (subacromial, subspinous)
B.	Traumatic defects		
	Subluxation	I.	Stub
	Luxation	II.	Subcoracoid dislocation
		III.	Subglenoid dislocation
	Complication		Arthropathy following dislocation

I. SUBLUXATION OR STUB

The characteristics of subluxation or stub are exemplified by the following instances:

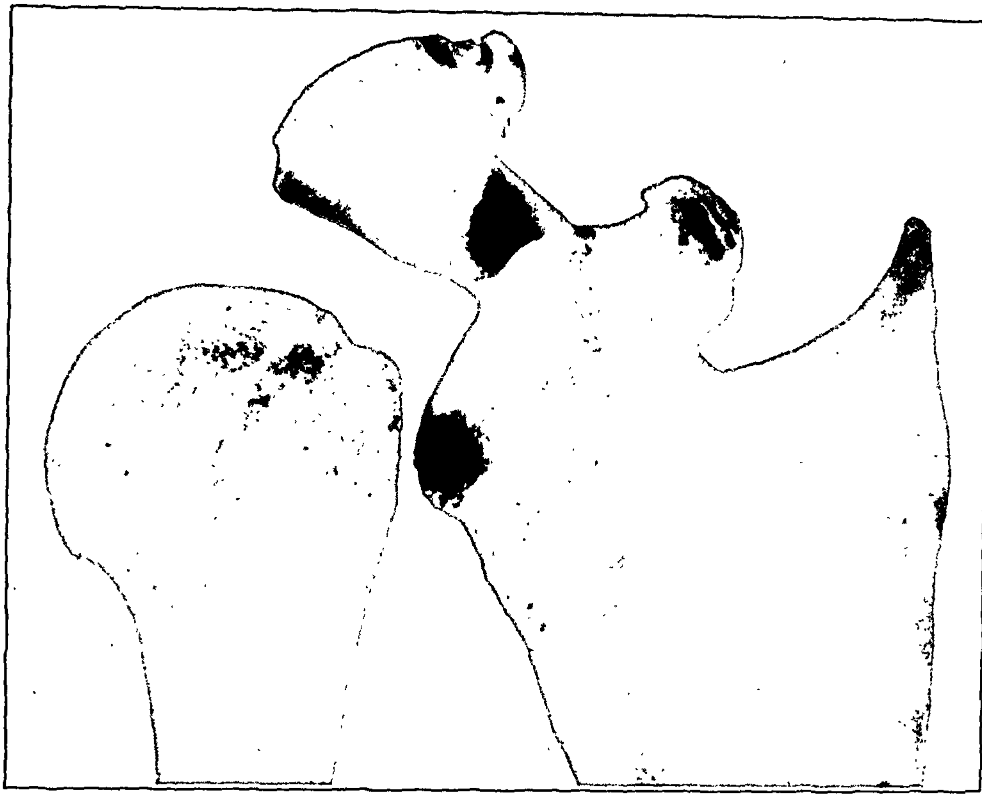

FIG. 1

Right humerus seen from behind, and glenoid surface of right scapula. W. R. U. 1751, male, negro, aged forty-eight years. Stub of shoulder. Note old healed compression fracture of ventral margin of glenoid, with slightly proliferative area on dorsolateral margin of articular head and smooth, flattened deformity of the greater tuberosity.

W. R. U. No. 1751, male, negro, aged forty-eight years, right shoulder (Fig. 1). In physical appearance the right shoulder was flattened, the humeral head formed a definite visible convexity just above the axilla, the acromion plainly projected laterally and there was some abduction and lateral rotation.

Examination of the macerated bones shows that the ventrolateral glenoid border is definitely roughened and slightly depressed. It is clearly the site of a healed compression fracture associated with dislocation. The dorsal margin of the humeral head shows proliferative change which extends, as a small, smooth, flattened area, to the adjacent part of the greater tuberosity. The humeral defect points to deformity with external rotation. The circumstantial evidence suggests hyperactivity of the infraspinatus associated with subscapularis weakness.

Almost identical with the above is the left shoulder, W. R. U. No. 1841, male, negro, aged forty-five years. It is probable that the real age of this patient was nearer thirty-five years. The stave of the ventral glenoid is not so extensive but is equally well defined. There is the same smooth, flattened area on adjacent aspect of the greater tuberosity. The physical appearance of the shoulder and the condition of subscapularis and infraspinatus muscles were probably precisely similar to those of No. 1751.

W. R. U. No. 1491, male, white, aged fifty years, was so fat that no superficial indication existed of the left shoulder defect. The ventral glenoid border is completely chipped off below for a distance of one centimeter, with surrounding recent bony proliferation. It is clearly the site of fairly recent stubbing fracture. On the surgical neck of the humerus, a little below and medial to the lesser tuberosity, there is a large exostosis simulating avulsed bone. Erosion is beginning on the dorsolateral margin of the humeral articular head with circumstantial evidence of unnatural external rotation.

The fourth and last of this class is the left shoulder of W. R. U. No. 1795, male, white, aged forty years. The physical appearance of this shoulder was precisely like that of Nos. 1751 and 1841. On the macerated skeleton there is absence of approximately one centimeter of the ventral glenoid margin which gives the impression of absorption after compression fracture. Humeral head and adjacent greater tuberosity show slight erosion. Like No. 1491, the demonstrable defect on the healed ventral glenoid margin permits undue external rotation at the shoulder joint.

The right glenoid of this skeleton shows a lesion very suggestive in the consideration of stubbing fracture. On the ventral aspect of the glenoid neck or base is a quiescent eroded and undermined area as of old bursitis in the subscapularis synovial extension, predisposing the ventral glenoid margin to fracture.

FIG. 2

Left humerus seen from behind and ventral aspect of scapular neck. W. R. U. 565, male, white, aged fifty years. Stub of shoulder. The recent origin is demonstrated in the new callus on the glenoid neck and the extensive erosion of humeral head which presents the typical granular appearance of freshly caused destruction.

FIG. 3

Left humerus seen from behind and ventral aspect of scapular neck. W. R. U. 284, male, white, aged seventy years. Subcoracoid dislocation. Note the old-standing waxy bone proliferation on glenoid neck with sharpening of ventral glenoid margin, together with waxy, healed erosion on adjacent areas of humeral head and greater tuberosity.

II. SUBCORACOID DISLOCATION

In the subcoracoid group of dislocations, the laterally rotated humerus hangs over the ventral margin of the glenoid with an obvious functional defect of the subscapularis muscle.

W. R. U. No. 565, male, white, aged fifty years, shows a recent though typical dislocation of the left shoulder joint, with abduction and external rotation each of about forty-five degrees' extent (Fig. 2). The ventral glenoid margin itself is undamaged but the ventral surface of the glenoid neck shows an extensive mass of recent callus. The dorsolateral part of the articular humeral head and the adjacent part of the greater tuberosity are mutilated by an erosion of considerable extent which penetrates deeply into the cancellous bone. The erosion is definitely confined to the dorsal part of the humeral upper extremity and does not extend to its upper surface. The distribution of this erosion is the distinctive feature by which, on the macerated skeleton, subcoracoid and subglenoid dislocations are distinguished. Recent as the condition must be, a nearthrosis is in process of formation.

W. R. U. No. 284, male, white, aged seventy years, presents, in the left shoulder (Fig. 3), a condition precisely similar to that shown by No. 565, but of considerable standing. There is condensation of compacta

over the ventral glenoid margin with waxy exostosis (old callus) over the entire ventral aspect of the neck extending to the base of the coracoid. There is a healed erosion with a waxy surface involving the dorsal margin of the humeral head and adjacent part of the greater tuberosity. This erosion is shallow and its surface waxy and polished. It is, therefore, totally unlike No. 565 in its actual features, though belonging to the same class of injury.

In W. R. U. No. 1078, male, white, aged forty years, the right shoulder is indistinguishable in physical appearance from the stubs of the previous chapter. But for a slight flattening and an elongation, so small as to escape attention unless specially searched for, there was no abnormality. We cannot state the physical condition of Nos. 565 and 284 since, in those early days of the collection, photographic and anthropological records were not made. On the skeleton of No. 1078, which turns out to be a subcoracoid dislocation less recent than No. 565 but not of as long duration as No. 284, there is a crescentic-shaped erosion of the ventral glenoid margin and the neck beneath it where there is a small mass of fairly recent callus. Again, on adjacent areas of humeral head and greater tuberosity, posteriorly, there is a quiescent, slight waxy erosion. The specimen is then a frank subcoracoid dislocation in which the arm is maintained in a position of abduction and external rotation, each of about forty-five degrees. The

FIG. 4

Right humerus and ventral aspect of glenoid neck. W. R. U. 1770, male, white, aged forty-eight years. Subcoracoid dislocation. Note the marked erosion on humeral head and the eburnation of glenoid with very little proliferation.

nearthrosis was, during life, gradually increasing its range of motion commensurate with the degree of erosion.

W. R. U. No. 1770, male, white, aged forty-eight years, concludes our series of subcoracoid dislocations (Fig. 4). The condition was readily diagnosed on the cadaver by the characteristic flattened shoulder and elongated upper arm. On the skeleton we find erosion of the ventral aspect of the glenoid neck extending to the base of the coracoid. The angle of the coracoid had been fractured but this must have been a greenstick type, for it is healed in perfect position. A part of this eroded area has a smooth burnished surface apparently from friction of long duration. The non-burnished areas show some evidence of inflammation in their honey-combed condition.

The foregoing are all examples of subcoracoid dislocation with the upper extremity of the humerus closely tucked under the coracoid process. We now turn to a group in which the humeral head lies against the glenoid margin lower down. Of the four examples, only the last two (Nos. 274 and 1538) are so situated that they would be recognized as subglenoid at once,—namely, that class in which the dislocated humerus fails to slip closely up under the coracoid process.

III. SUBGLENOID DISLOCATION

The most apt way to describe the four following specimens is that, in the first and second, the humeral head has slipped down somewhat from the subcoracoid position close under the coracoid process, whereas, in the third and fourth, the humeral head is so definitely anchored on the lower part of the glenoid margin that there is no question of the distinction between them and the subcoracoid type.

W. R. U. No. 363, male, white, aged sixty-four years. The right shoulder shows erosion of a portion of the lower ventral aspect of the glenoid neck and margin. The eroded surface is polished and has slight peripheral proliferation. Adjacent parts of humeral head and greater tuberosity are likewise eroded slightly and the eroded surface is polished. It extends upward on the dorsal aspect of the bone, higher than in previously described specimens but not so high as to reach the top, as in Nos. 274 and 1538.

W. R. U. No. 1022 is our only female example. It comes from a negro woman of forty-six years. On the emaciated cadaver the right humeral head lay well below the clavicle and coracoid process. The condition was diagnosed at that time, however, as subcoracoid dislocation. In this specimen there is not the usual erosion of the glenoid margin. There is, instead, a disc of newly formed bone, about the size of a quarter, forming a nearthrosis on the ventral aspect of the glenoid neck. The glenoid surface itself is covered with bony proliferations associated with a profuse development of synovial tags. The humeral head is also partly covered with bony proliferations. There is no erosion of head or of greater tuberosity. In this characteristic, No. 1022 differs from the other specimens in

FIG. 5

Left humerus and ventral aspect of glenoid neck. W. R. U. 274, male, white, aged forty-five years. Subglenoid dislocation. Note features quite similar to those of subcoracoid dislocation, but involving upper rather than posterior part of humeral head and lower rather than mid-ventral aspect of glenoid neck.

our collection not in principle so much as in degree. The erosions of glenoid margin and of humerus are incidents to the relative positions of the bones. They are not essential but they must prejudice the results of treatment.

W. R. U. No. 274, male, white, aged forty-five years (Fig. 5). The left shoulder joint shows a healed recent erosion of the lower ventral glenoid margin and neck. A similar recent but very extensive healed erosion involves adjacent parts of the back and upper surface of humeral head and greater tuberosity. This extension to upper surface, characteristic of this and the next specimen, is the distinctive feature of the subglenoid dislocation. The humeral erosion in No. 274 is rough but not polished. There must have been marked abduction but little external rotation.

This is not a classic picture of subglenoid dislocation but it clearly illustrates the features of the condition which has been rather inadequately described in standard works.

W. R. U. No. 1538, male, Indian, aged sixty-three years, is the last of our subglenoid series. In the cadaver a slight flattening of the left shoulder, without other deformity or even recognizable lengthening of upper arm, was the sole indication of damage. The outward evidence in No. 1022 was far more pronounced than in this specimen. After preparation of the skeleton, we found on the lower ventral part of the glenoid margin a healed eroded area about one centimeter long which involved also a portion of

the neck. The usual erosion at back and upper surface of humeral head extending to the greater tuberosity is present and is now quiescent and waxy.

LUXATION COMPLICATED BY ARTHROPATHY

Before finishing the description of dislocation of the shoulder, mention should be made of a single specimen of unknown origin except that it was obtained from a white male beyond fifty years of age. This specimen of right shoulder joint, No. E361, shows a glenoid surface completely eroded and a semilunar nearthrosis on the ventral aspect of the neck, merging by a rounded margin with the glenoid proper. The humerus suffered a comminuted fracture of the anatomical neck which never united and is associated with a T-shaped deformity of the upper shaft. It is strange that the greater tuberosity survived. There is much ossification in the joint capsule and the long tendon of the biceps is completely ossified. The detached anatomical head was dislocated and lies in the subcoracoid position.

THE PRINCIPLES OF TRAUMATIC DISLOCATION

The injury that gives rise to traumatic defect of the shoulder joint relationships apparently consists usually of a stubbing fracture of the ventral glenoid rim. There is, at this site, an extension of the synovial membrane of the shoulder joint under the tendon of the subscapularis muscle, and it may be that an antecedent bursitis with consequent thinning of the bony glenoid margin may predispose to the damage.

Since our cases of stubbing fracture are accompanied by external rotation of the humerus, it is plain that some functional defect of the subscapularis muscle accompanies and indeed may be an integral part of the injury. True enough, No. 1022, which has no erosion of the glenoid margin, also showed far less external rotation of the humerus than the others. Indeed this is the only one in which anything like complete pronation was possible among the eight of which there are photographic and anthropological records (*i.e.*, Nos. 1751, 1841, 1491, 1795, 1770, 1022, 1078, and 1538). In this specimen the subscapularis had suffered practically no functional interference.

Nos. 565 and 284, of which we have no photographic records, require a little further explanation. At first sight they are quite similar to No. 1022 in that the glenoid margin is undamaged. They differ from No. 1022 in having an eroded humerus. They are, then, examples of a dislocation accompanied by functional defect of subscapularis but without stubbing fracture.

The characteristic indicator of functional defect in subscapularis is external rotation of the humerus with consequent inability to pronate the hand. We would not confuse the reader over these two movements, axial rotation of the upper arm and pronation-supination of the forearm. They are quite different, but the former greatly enhances the value of the latter movement. The anatomical defect in external rotation is an erosion of the humerus, but not necessarily of the glenoid margin. It would seem that

the unnatural pull of the dorsal scapular muscles, and the functional disadvantage in which the subscapularis is involved, bring about a pressure erosion of the humerus and glenoid margin, together with a locking of the arm in external rotation.

The two further stages of the traumatic dislocation—namely the subcoracoid and subglenoid forms—are merely the expression of physical anchorage of the shoulder in its new position. If the mid-ventral glenoid margin gives way and the back of the humerus be eroded, the subcoracoid form results. If, however, the lower ventral glenoid margin is involved and the upper surface of humerus is eroded, the subglenoid form results. There is, certainly, in our series, no evidence of transition from one to the other, such as is postulated in classic descriptions of the condition. It is apparent that the type of dislocation is determined by the details of the original injury.

In luxations complicated by arthropathies, we have a characteristic picture of bone destruction and proliferation, with normal relations entirely lost and features which are in part the result of bone defects and in part the consequence of damage to capsular structure and function.

In the formation of the nearthrosis the most striking feature is the evidence of fairly recent erosion of the humeral head associated with evidence of old healing in other parts of the joint. This can only mean that erosion continues long after the original trauma, when marked pain and muscle spasm have disappeared or are replaced by chronic "rheumatism" and muscle contracture.

TRAUMATIC SUBLUXATION OF THE SHOULDER JOINT

Although there is obviously no definite evidence for the following assumption, it is reasonable to infer that a certain proportion of these cases classified as traumatic defects were recurring subluxations, and others permanent unreduced subluxations. Of the twelve cases reported here, W. R. U. No. 1751, No. 1841, No. 1491, and No. 1795, classified as stub, may be rightfully considered as having been cases of recurring subluxations, as demonstrated by the position the component parts of the shoulder joint assume in the physiological and subluxated positions. It is possible that some of the cases described as subcoracoid dislocations may be grouped in the category of recurrent dislocations, particularly No. 565, and probably No. 284, in which there is evidence of a fairly recent process of the formation of a nearthrosis.

Roentgenologic examination of all the shoulder joints classified as stub, with the scapula and humerus in their physiological and subluxated relations, fails to reveal any evidence whatever of defect in the humeral head or the glenoid. In a recent paper, Henderson[7,8] stated that defects in the glenoid cavity have been advanced as a cause of subluxation, but that proof of this by roentgenograms or by observation at operation has been lacking.

The writer examined a large number of roentgenograms taken to check reductions of traumatic dislocations of the shoulder in a large clinic and, with the exception of definite evidence of fracture in the head or neck of the humerus or in the scapula, there was not a single case in which injury to the humeral head or glenoid could be demonstrated. Surely, with the large number of traumatic subluxations occurring and roentgenograms taken after reduction, many of these reported negative for bony injury must have sustained a trauma similar to that demonstrated in our series. When one considers the difficulty of obtaining roentgenologic detail in the shoulder joint, especially in the anteroposterior plane, such defects as found in this first series may easily be overlooked.

Of the various measures proposed for the relief of recurring dislocations, it is invariably inferred that the subluxation is due either to laceration or relaxation of the joint capsule. However, the incidence of twelve in approximately eighteen hundred complete skeletons, or about six-tenths of one per cent., must be given due consideration as an important etiological factor in these cases. In pathological dislocations, such as resulting from poliomyelitis, Erb's palsy, etc., there is a definite relaxation of the joint capsule; but in traumatic dislocations, bony injury or laceration of the capsule, or both, are the etiological factors.

Reviewing the surgical operations described for the recurring cases, there are in the main two types: first, those which aim to reefing and repair of supposedly relaxed and lacerated joint capsules, as exemplified by the Thomas operation[2]; and second, those which limit the range of motion of the shoulder joint between the humeral head and glenoid by improvised check ligaments,—such as the Clairmont[3], and Henderson[7] procedures; or by bone block,—such as the Speed[4] operation.

Henderson subdivides these operations into five types: first, those performed on the bony structures, such as the Speed operation; second, those performed on the capsule, such as the Thomas operation; third, correction by muscle transference and muscle lengthening, which is exemplified by Clairmont's operation; fourth, check and block operation, such as the Gallie and Le Mesurier method[5]; and fifth, suspension operations, which are exemplified by the Henderson procedure. Without attempting to produce any actual statistics of end results, an inquiry has shown that there have been more failures from capsule reefing and repair operations than from those with check ligaments and bone-block procedures. Is it not possible, therefore, that many of the failures following capsulorrhaphies may have been due to the fact that the surgeon was dealing with a case of bony defect, as described in our series, rather than to capsular trauma or relaxation?

SUMMARY

1. Herein are described twelve instances of traumatic dislocation of the shoulder joint. Eight have been carefully studied: first in the cadaver, next by dissection, and lastly on the macerated skeletons. The other four are known only by the skeletons.

2. These twelve lesions emanate from a collection of 1826 complete skeletons of known individuals. The high percentage is probably due: first, to the class of patient who does not readily seek medical advice for a disability; and, secondly, to the relatively minor degree of disability apparently suffered by most of the twelve.

3. The classic description of the production of traumatic shoulder dislocation is not borne out by these examples.

4. In the original injury the humeral head has been forced over the glenoid margin in the region of the subscapular bursa. This is accompanied by either a stubbing fracture of the ventral glenoid margin or by a functional disability of the subscapularis muscle, or both.

5. In the subluxation or stub, the healed glenoid margin is no disability but the functional damage sustained by the subscapularis becomes the important feature. The humerus is externally rotated and is slightly eroded on its dorsal aspect adjacent to the greater tuberosity, even though the head never leaves the glenoid cavity. This condition may escape notice or be diagnosed as rheumatism.

6. Subscapularis bursitis seems to have some influence in predisposing the joint to traumatic dislocation through thinning of the glenoid margin.

7. In the true luxations the head leaves the glenoid and the final category depends upon the site of glenoid injury. If the mid-ventral margin is damaged, subcoracoid dislocation results; if the lower ventral margin is affected, subglenoid dislocation occurs. In such conditions the humeral erosion is more or less deep, depending upon extent of glenoid damage and muscular action.

8. This humeral erosion apparently continues long after the original pain and muscular spasm have given place to "rheumatism" and muscular contracture.

9. Stubbing fracture of the ventral glenoid margin, old synovitis of the subscapularis bursa, and traumatic functional deficiency in the subscapularis muscle are the three contributing causes to traumatic dislocation of the shoulder, so far as can be ascertained from our material.

10. It may be inferred that many of the cases herein described, especially those classified as stub, were cases of recurring subluxations of the shoulder joint. In view of the fact that we have definitely demonstrated the presence of bony defect, operative correction should be planned with view to correction of the subluxation by check ligaments and bone-block operations rather than by capsulorrhaphies.

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LIVER MEAL IN THE TREATMENT OF AMYLOIDOSIS IN SURGICAL TUBERCULOSIS*

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The development of amyloidosis in surgical tuberculosis is comparatively rare, but when it occurs it almost always terminates fatally. Very few patients have been known to recover. The very few cases of recovery from lardaceous disease that have been reported[1] followed radical surgical procedures. Hence it has always been justly feared as a complication. It results from long continued suppuration following the breaking down of an abscess and the formation of one or more sinuses which have continued to discharge over a long period of time.

This condition is accompanied by marked emaciation, waxy pallor, and prominence of the abdomen due to the gradual enlargement of the liver and spleen, which may occur to a marked degree. Prominence of the superficial abdominal veins is always noted; ascites is frequently a distressing complication. Secondary anaemia, progressing to the extreme in many cases, is always present. Large quantities of albumen are found in the urine. Death follows at the end of several months from exhaustion, failure of the portal circulation and cardiac failure.

The beneficial results from the use of liver meal in these cases were found by us as if by accident. The advantage of its use in secondary anaemia was realized and because of this fact we began its administration in Case 1 of our series about two years ago in an effort to combat this steadily progressive anaemia.

Newton[2] noted significant improvement of the anaemia and of the general condition of patients with pulmonary tuberculosis following the use of a liver extract. Grayzel *et al*[3] showed that the addition of small quantities of powdered whole liver to the diet retarded definitely the production of amyloidosis in white mice. Several investigators[4] have reported favorable results in cases of pulmonary bone or joint tuberculosis, treated with powdered whole spleen, splenic extract, or a mixture of spleen and bone marrow.

In this preliminary report we are presenting seven cases which, at the time of the beginning of treatment with the liver meal, presented definite symptoms and physical signs of amyloidosis in varying degrees of severity, —*i.e.* emaciation, waxy, yellowish pallor, a severe secondary anaemia, large prominent abdomen with markedly enlarged and firm liver and spleen, and large quantities of albumen in the urine, with waxy casts in most cases.

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The active tuberculous infection of the bones, complicated by several profusely discharging sinuses, had been present for two or more years. Furthermore, the Congo-red test for the diagnosis of amyloidosis as described by Bennhold and others[5] was positive in each case. Three patients had far advanced amyloidosis secondary to Pott's disease. The other four presented a moderately advanced type of amyloidosis: two were secondary to tuberculosis of the hip joint, and the remaining two to tuberculous osteitis of the knee joints. All of the seven children were doing poorly and were growing worse rapidly before the institution of the treatment.

The specific therapy consisted of the administration of a concentrated powdered whole liver in three daily doses of four grams each for a period of two years. In addition the children were confined to their beds and received daily salt baths and dressings, and heliotherapy or ultra-violet light therapy. An adequate diet including all the vitamins was given.

RESULTS

Of the seven children treated, two died; the remaining five showed no clinical evidence of amyloidosis at the end of twelve to eighteen months of treatment.

One child, after five months of treatment, died of an intercurrent pulmonary infection. The demise of the other child occurred fourteen months after the institution of this therapy. In this patient, there was evidence of resorption of the amyloid substance. This was shown by a significant reduction in the size of the liver and the spleen. The palpable portion of the liver decreased in length from seven to three inches, and that of the spleen from six to two inches. The hepatic measurements were made from the mid-point of the right costal margin, and those of the spleen from the mid-point of the left inferior border of the ribs. Following the recession of these organs, recurring ascites set in, which did not respond to medicaments or to frequent paracentesis. This complicating condition was probably responsible for death due to cardiac failure. In this child, therefore, there is some reason for believing that, under the influence of this particular therapy, the amyloid was in the process of being gradually resorbed. It may be that the recurrent ascites was caused by portal obstruction due to a replacement fibrosis of the resorbed amyloid. An autopsy was refused by the family.

The other five children are still alive. They all showed definite improvement within three months. After this period, progressive betterment was noted in their general condition, in their tuberculous infection, and in the amyloidotic symptomatology. The favorable retrogression of the amyloidosis proceeded at a much greater pace than the tuberculous infection. It was observed that the recession in size of the liver and of the spleen occurred even during the active stage of the infection as determined by elevation of temperature and by the profusely discharging sinuses. By the

eighteenth month, the general appearance and state of nutrition of these patients was good; the secondary anaemia was mild or had even disappeared entirely; the abdomen was not prominent, and the liver and spleen were no longer palpable. Thus no clinical symptom characteristic of amyloidosis was present. However, the Congo-red test was still positive, indicating that sufficient lardaceous material was present in the organs to absorb the dye and remove it completely from the blood.

CASE 1. J.G. This was the first case in which the treatment with liver meal was instituted. The treatment was begun with the idea of improving, if possible, the extreme state of secondary anaemia.

This boy is fifteen years old at the present time. He had a well marked lumbar Pott's disease with discharging sinuses in left iliac region. These sinuses had discharged continuously for three years and during much of this time he had an afternoon temperature of 101 to 102 degrees and physical signs of amyloidosis developed. He began to grow worse and two years ago his condition became so serious that death seemed imminent. At that time the sinuses were discharging freely; his temperature continued. He was extremely pale and waxy in appearance. The abdomen was markedly distended; the superficial veins appeared prominent; the liver could be palpated at the line of the umbilicus, and the spleen two and one-half inches below the free border of the ribs. Albumen in the urine was four plus. Ascites then began to develop to a considerable degree. He had occasional hemorrhages from the nose and rectum and had vomited blood; there was no hemoptysis. His hemoglobin was forty-five per cent.

On April 14, 1929, the treatment with liver meal was begun; four grams were given three times a day. This treatment was continued during the following months and, much to our satisfaction, a definite improvement in the boy's general condition was noted. Five months after starting treatment the abdominal distention had diminished; there was no dyspnoea or cyanosis. The dilatation of the superficial abdominal veins had disappeared, the liver and spleen had noticeably diminished in size, and no ascites was present. In November 1929, two months later, the hemoglobin had risen to fifty-eight per cent. and his general condition had markedly improved; the sinuses had been closed for three months. Two months later, in January 1930, he was allowed up. At this time the liver was palpable two inches below the free border of the ribs; the spleen was barely palpable; the sinuses remained healed. Two months later the liver was palpable one and one-half inches below the border of the ribs and the spleen was not palpable. The boy's general appearance was strikingly improved. His color good and he was active and up and about daily. He had gained several pounds since the inception of the treatment.

At the present time the boy is the picture of health, and is going to school. He has splendid color; the abdomen is only slightly distended; the liver is palpable about one inch below the ribs, the spleen not palpable; no superficial abdominal veins are apparent; his hemoglobin is eighty per cent.; sinuses remain healed.

CASE 2. C.I. This boy was admitted to Neponsit seven years ago with tuberculosis of the left knee and right ankle. He was in very poor condition, both the knee and ankle were markedly thickened, swollen, and indurated; and there were numerous freely discharging sinuses about both joints. The boy was emaciated and very anaemic. Boy continued to grow worse until, in March 1928, the child was thin; his appetite was poor; the abdomen was very prominent, with marked dilatation of the superficial veins. The liver was palpable three inches below the free border of the ribs and the spleen two inches below the ribs. The hemoglobin was fifty-five per cent.; the red-blood-cell count, 2,550,000. At this time, the liver-meal treatment was instituted, one dram given three times a day.

From this time on the boy began to improve and in June 1928, three months later, the examination showed the abdomen was still prominent, with moderate dilatation of

the superficial veins. The liver had diminished in size to a little less than two inches below the free border of the ribs, the spleen was palpable one inch below the free border of the ribs. The hemoglobin had increased to seventy-five per cent. and the red blood cells to 4,450,000. In November 1928 the boy's condition was markedly improved; temperature was normal; he had gained eight and one-half pounds in a period of ten months. There was no distention of the abdomen, no dilatation of the superficial veins; liver and spleen were not palpable; the hemoglobin was sixty per cent.

In July 1930, the boy's general condition and appearance were excellent; there was no distention of the abdomen, and no dilatation of the superficial veins; liver and spleen were not palpable; and the hemoglobin had risen to eighty per cent. The sinuses in the ankle had entirely healed and there was only a slight discharge from the sinuses about the knee.

Case 3. E.L. This boy was admitted to the hospital in October 1928 in very poor condition. He had tuberculosis of the left knee and was wearing a Thomas knee brace with a high shoe on the opposite foot. The knee was markedly swollen and presented a typical fusiform appearance. There were numerous sinuses discharging freely about the joint. There was slight motion in the joint which was very painful. The liver was palpable two inches below the free border of the ribs, spleen was not palpable. Hemoglobin was thirty-five per cent., red blood cells 2,230,000.

In January 1929, the boy's general condition had not improved; he was markedly emaciated with pallor of the mucous membranes and finger nails; his appetite was poor. The abdomen was very prominent with dilatation of the superficial veins. The liver was palpable at a line with the umbilicus and the spleen was palpable about two inches below the free border of the ribs. The sinuses in the knee joint were discharging profusely; hemoglobin was thirty-five per cent., red blood cells 2,230,000. At this time the liver-meal medication was begun, one teaspoonful three times a day. The child soon began to improve: the discharge from the sinuses began to diminish, and the knee was less painful.

In June 1929, examination showed considerable improvement in the knee joint and less discharge from the sinuses and the boy's general condition showed a marked change for the better. There was slight distention of the abdomen; liver and spleen were not palpable. In September 1930 hemoglobin had risen to seventy-five per cent. The sinuses in the knee joint were entirely healed; liver and spleen were not palpable.

Case 4. M.N. This boy was admitted to the hospital in July 1926, with tuberculosis of the right hip and a large abscess in the upper third of the right thigh. This was incised, six ounces of greenish-yellow pus were evacuated, and the wound was closed with catgut sutures. Liver and spleen were not palpable at this time. In December 1927, the child's general condition was poor; he had lost considerable weight; appetite was poor; the skin was a yellowish-brown in color. The sinuses about the hip joint began to discharge freely; abdomen was distended: superficial veins were prominent; liver and spleen were each palpable one inch below the free border of the ribs. In January 1928, the child had failed still further, the liver was palpable about three inches, and the spleen one and one-half inches below the free border of the ribs. In March 1928 the same condition was present, hemoglobin had dropped to forty per cent.; red blood cells were 2,750,000 at this time. The liver-meal treatment was instituted, one dram given three times a day.

In August 1929 the boy's temperature was normal. Five months later he showed considerable improvement; temperature was normal; appetite was good; color of the skin and mucous membranes had shown a marked improvement; abdomen was not distended; liver was palpable about one and one-half inches below the free border of the ribs, and spleen was not palpable. One year later, in October 1929, the boy's condition was excellent; he had gained five and one-half pounds. There was no distention of the abdomen; the liver and spleen were not palpable. Hemoglobin was sixty-five per cent. In May 1930, the boy developed erysipelas and was very ill. He recovered and in September 1930 his hemoglobin had risen to seventy-five per cent., but there was some distention of the abdomen, with no dilatation of the superficial veins; the liver was just palpable below the free border of the ribs and the spleen was not palpable.

Examination of the boy in March 1931, showed a considerable improvement in his general condition; his lips and ears were regaining their color, his appetite had improved, his temperature had disappeared, and the discharge from the sinus was diminishing. The liver and spleen were not palpable and the hemoglobin was seventy per cent.

CASE 5. R.H. The child was admitted to the hospital in July 1927, in fair condition. He had an active pulmonary tuberculosis, with a very extensive kyphosis from the fourth dorsal to the second lumbar vertebrae, and discharging sinuses in the right groin with moderate discharge. He had a daily temperature of 99 to 101 degrees and an active cardiac disease. In December 1928 the condition was quite poor; liver was barely palpable; spleen was not palpable; there was a moderate discharge from the sinus in the right groin. In July 1929, the child's condition was fair; there was considerable distention of the abdomen; liver was palpable three inches below the free border of the ribs, spleen was barely palpable. In November 1929, the child's condition was about the same,—hemoglobin was fifty-five per cent., the liver had enlarged to the level of the crest of the ilium and the spleen was about two inches below the free border of the ribs.

At this time liver-meal treatment was instituted,—one teaspoonful three times a day. The heart became weaker, and the lung condition became very active; but, in spite of these conditions, the liver and spleen began to diminish in size. In January the liver was palpable two inches and the spleen one inch below the free border of the ribs. Because of a rule in the hospital against retaining such far advanced cases of pulmonary tuberculosis, the boy was discharged at this time and died shortly afterwards. A notable point in this case, in spite of the serious condition, was diminution in the size of the liver and spleen under treatment with liver-meal.

CASE 6. E.A. The boy was admitted to Neponsit in October 1925 in fair condition, with a discharging sinus over the left ilium. Previous to admission he had had a bone graft for Pott's disease in the lumbosacral region. In December 1926, the boy began to run an afternoon temperature, with less discharge from the sinus and with some tenderness and distention of the abdomen. This distention continued, with some discharge from the sinus, and with an afternoon temperature of about 102 degrees. In May 1927, the boy's condition was poor; pulse was rapid, and he had lost considerable weight; liver and spleen were not palpable. In December 1928, the child's condition was very poor, showing advanced amyloidosis; spleen was palpable two inches below the free border of the ribs; liver was palpable in line with the crest of the ilium; hemoglobin was thirty-eight per cent. At this time liver-meal treatment was instituted,—one teaspoonful three times a day.

In January 1930, the child had evidently improved since the administration of the liver meal; the liver had diminished in size to a line with the umbilicus and the spleen was palpable just above the line of the umbilicus. There was beginning pinkness in the cheeks, fingers, ears, and lips; but at this time the boy began to develop ascites. Frequent tappings were necessary to relieve the distress in breathing. When the abdomen was greatly distended it was impossible to feel the liver and spleen, but each time the abdomen was tapped it was found that the liver and spleen were diminishing in size. In March 1930, patient was much more comfortable; there was marked improvement in the color of the lips and ears, and palpation of the liver showed that it had diminished in size to about one inch above the umbilicus.

In October 1930, hemoglobin had risen to fifty per cent., but the ascites continued to be a very distressing symptom and his reaction to the tapping was not satisfactory. Heart again became poor and the child was distressed for breathing at the time. In January 1931, following the tapping of the abdomen, the liver was found to be two inches and the spleen one inch below the free border of the ribs. The heart action was poor and irregular and, on January 14, 1931, the boy died from cardiac failure.

CASE 7. S.B. The boy was admitted to Neponsit Hospital May 1926 in fair condition, wearing a long plaster spica. The plaster was removed, the hip was in 170 degrees of extension and fifteen degrees of abduction. There was slight motion at the hip joint. There were several healed scars about the hip as a result of operations before

admission, and there was a sinus behind the greater trochanter which was discharging freely. The first few months the boy showed some improvement, but gradually grew worse and, in July 1930, he was in very poor condition; abdomen was prominent with enlargement of the superficial veins; liver was palpable one and one-half inches and spleen about half an inch below the free border of the ribs. Hemoglobin was forty per cent.; the sinuses were discharging freely, and the boy was running an intermittent temperature.

At this date, the liver-meal treatment was instituted,—one dram three times a day. From this time on, the boy began to show steady improvement. In September 1930, the sinuses were all healed about the hip joint; motion in the joint without pain had increased; extension was possible to 160 degrees, flexion to 115 degrees. In November 1930, the sinuses were healed; flexion at the hip was possible to 100 degrees; there had been no recurrence of the active symptoms.

In January 1931, the child was in fine condition. All the sinuses about the hip joint and left shoulder remained healed; liver was just palpable below the free border of the ribs and spleen was not palpable; distention of the abdomen had disappeared and the superficial veins were not prominent; hemoglobin was fifty-five per cent. Examination on March 25, 1931, showed the boy to be in fine condition,—his complexion was good; he had gained considerable weight; there had been no recurrence of the process in the left shoulder; liver and spleen were not palpable; there was 160 degrees of extension in the right thigh and fifteen degrees of adduction; flexion was possible to ten degrees; hemoglobin was seventy per cent; the sinuses remained healed.

The x-ray in this case originally showed marked disease of the right hip joint with destruction of the head of the femur and marked destruction and enlargement of the acetabulum. In November 1930, four months after the institution of the liver meal, it was noted that there was improvement in the appearance of the focus in the acetabulum. An artificial shelf had formed in the upper border of the acetabulum which would prevent subluxation at the neck of the femur. In February 1931, the x-ray showed a marked increase in the healing process taking place within the acetabulum.

DISCUSSION

Amyloidosis is a condition which is secondary to a long continued suppurative or wasting disease. Its etiology is still unknown. Some believe it to be a degenerative condition, resulting from changes in the organs due to cellular autolysis. Others consider it to be secondary to a protein metabolic disorder[6] in which the amyloid substance or its precursor is deposited in the reticulo-endothelial system of the various organs[7,3].

The development of amyloidosis may be viewed tentatively as follows: In an infection or wasting disease, there occurs an excessive destruction of cells. The products of this disintegration must be metabolized to their end products, or to a form that can be utilized or excreted by the organism. The site of this endogenous metabolism is as yet unknown. However, it is likely that an important rôle in this process is played by the reticulo-endothelial system. The latter consists of fixed and circulating cells which are scattered throughout the body, but are present in a greater measure in the liver, spleen, and kidneys. These cells probably possess chemical substances, which may be of the nature of ferments or enzymes, which either disintegrate or transform the foreign or toxic substances into a form which can be utilized by the tissue cells, or which can be eliminated through the excretory channels. However, when even this system cannot alter the particular substance either through its chemical inability or through exces-

sive production of this substance, then the latter is deposited in the reticulo-endothelial system. The deposition continues just so long as the body is overwhelmed with the non-metabolized material, since the body cannot eliminate it as fast as it is being formed.

Then, there occurs a progressive accumulation of the amyloid substance, which after a time interferes with the function of the organs. Mechanical pressure results in atrophy and death of the normal tissue cells of the organs in which this material is lodged. The amyloid material, after its infiltration, undergoes progressive changes in its composition[8] and, as it goes through several stages in its formation, becomes more stable and more resistant. Formerly it was considered to be a permanent infiltration. Recently clinical[1] as well as experimental evidence[9] has shown that it can disappear, if the exciting cause is removed before advanced changes set in.

The manner in which the liver preparation affects the resorption and the disappearance of the amyloid material is not as yet known. It is possible that the powdered liver contains an active principle which participates directly or indirectly in its catabolism. The liver is well supplied with reticulo-endothelial cells. Furthermore, there is some experimental evidence that the Kupffer cells of the liver, which are part of this system, have the capacity of disintegrating the lardaceous substance. It may be, then, that with the administration of the liver, the organism is supplied with additional amounts of specific chemical substances which the cells of this system possess. The exogenous supply supplements the relatively similar endogenous material, which is inadequate under the circumstances. This tentative explanation may possibly account for some success reported by others[4] with the use of spleen and bone marrow, which contain reticulo-endothelial cells.

SUMMARY

Powdered whole liver was used in cases of general amyloidosis secondary to bone tuberculosis. Seven children were given this therapy. One died shortly after the treatment was started. Another child died after fourteen months of treatment, although retrogression of the lardaceous disease was evident. In this instance, probably irreparable changes set in prior to the inception of the therapy. The remaining five showed no clinical signs of amyloidosis after treatment for a period of eighteen months.

In presenting this subject, it should be stated that the study was carried on at the Neponsit Beach Hospital for surgical tuberculosis in children, at Neponsit, Long Island, in collaboration with Dr. Harold Grayzel, who is in charge of the Pediatric Service at the hospital, and to whom much of the credit is due for the work presented in this report.

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LATE RUPTURES OF EXTENSOR AND FLEXOR POLLICIS LONGUS TENDONS FOLLOWING COLLES' FRACTURE*

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Late spontaneous rupture of the extensor pollicis longus tendon is a rare complication of Colles' fracture, having been reported only twenty-seven times in the literature. However, the writer has been unable to find a reported case of late spontaneous rupture of the flexor pollicis longus tendon following Colles' fracture. One case of late rupture of extensor pollicis longus and one of late rupture of the flexor pollicis longus tendons are reported.

Subcutaneous tendon ruptures at the wrist are relatively uncommon from all causes. However, rupture does occur as a result of disease processes and trauma. Mason has recently made a thorough study of rupture of the tendons of the hand.

A normal tendon is so strong that, when great strain is placed upon it, rupture of the fibers is rare. If it occurs at all, usually, either the periosteal insertion of the tendon gives way, often carrying with it a fragment of subjacent bone (Hunt); or rupture occurs at the musculotendinous junction (Odermatt, Adams); or the bones fracture; or subluxation occurs (Honigmann). Adams reported a case demonstrating the great strength of tendon fibers. A seaman caught his right third and fourth finger tips in a door jamb. On jerking his hand away, he suffered a traumatic amputation at the distal interphalangeal joint of the third right finger and with it pulled away "fifteen inches" of the flexor profundus digitorum tendon and some muscle fibers. The rupture in this case occurred, not in the tendon, but at the musculotendinous junction.

For rupture of a wrist tendon to occur, it must either be damaged by disease processes first, or follow trauma, single or multiple. Pathological conditions predisposing to tendon rupture are tuberculous tenosynovitis (Kanavel), gonococcic tenovaginitis (Melchior), syphilis and tumors of tendons (Odermatt). A discussion of necrosis of tendons following a suppurative tenosynovitis will not be considered in this paper.

Mason, quoting from Kanavel's files, reports that, out of twenty-one available records of tuberculous tenosynovitis in the hand, rupture or impending rupture of tendon was noted in ten instances. Only one case of gonococcic tenovaginitis causing rupture of a hand or wrist tendon, reported by Melchior, could be found. Syphilis was mentioned as a possible cause of wrist tendon rupture by Odermatt, but no reported case could be found. Tumors of tendon were also mentioned by Odermatt as a possible cause of rupture and, although numerous reports of cases of tendon and tendon-

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sheath tumors were found (Weir, Russell, Mathews, White, Kurtz, Burman and Milgram), none of these had led to tendon rupture.

Trauma causes by far the largest number of tendon ruptures at the wrist. Lacerations from external forces with severance of tendons is not an uncommon experience, especially in the field of industrial surgery. Excluding this type of injury, the condition which probably causes the largest number of wrist tendon ruptures is drummer's palsy, first described by the Germans as "*Trommlerlähmung*", and the tendon practically always involved is the extensor pollicis longus. It had been noted by German army surgeons that a number of drummers, especially the younger ones, developed a paralysis of the extensor pollicis longus tendon, usually on the left hand. At first this was considered a paralysis of the muscle, but Düms showed it to be a rupture of the tendon. The rupture follows a chronic tenosynovitis, resulting from the repeated trauma to the tendon, by the particular method of holding the drumsticks and the vibratory motion set-up in it. This condition has occurred in occupations other than that of drummers, such as,—tailoring (Hunt), carpentering (Barnes), and cane-making (Duplay). The pathogenesis, namely chronic tenosynovitis, is essentially the same in these, as in drummer's palsy.

A study of the anatomy of the extensor pollicis longus tendon will help in an explanation of this condition. It arises from the lateral part of the middle third of the ulna, passes downward and lateralward, ending in a tendon which passes through a separate compartment in the dorsal carpal ligament, which holds it in a narrow bony groove, on the back of the radius. After emerging from this compartment, it forms an angle obliquely around the lateral bony ridge of the radial groove, crossing the tendons of the extensor carpi radialis longus and brevis, and is inserted into the base of the distal phalanx of the thumb. On the wrist it forms the ulnar-bounding tendon of the anatomical snuff-box.

The chronic tenosynovitis occurs at the distal border of the radial groove where the tendon turns obliquely lateralward around the lateral bony ridge of the radial groove. The degenerative changes, consisting of swelling, inflammation, and aseptic necrosis, cause the tendon to rupture during a spasm of drumming, or during no strenuous exertion, as merely putting the hand in the pocket in search of an article, illustrated in the case reported by Hunt.

Duplay in 1876 seems to have reported the first case of subcutaneous tendon rupture in the wrist, in a woman thirty-six years of age, a cane-maker, who fell while carrying a bundle of canes, causing a violent torsion of the right thumb. There was immediate inability to extend the thumb. At operation, he was unable to bring the separated tendon ends together, so made a buttonhole in the extensor carpi radialis longus and sutured the distal end of the extensor pollicis longus in it. Despite a subsequent infection, good function was present in the thumb in less than seven weeks from time of operation.

Another trauma causing tendon rupture in the wrist is Colles' fracture. Here there is but a single injury and not a series of repeated minor traumata

to the tendon such as occur in the above named conditions, producing chronic tenosynovitis.

Compared to the many wrist fractures continually encountered, there are very few late ruptures of the extensor pollicis longus tendon as a sequel. Kleinschmidt, in a review of the literature up to 1929, found a total of twenty-five reported cases. Coenen later reported a case occurring in a fifty-seven-year-old woman. Lülsdorf, in 1929, reported a case occurring in a fourteen-year-old girl and these, with the case here reported, make a total of twenty-eight.

The condition may occur at any age but is most common after thirty, the youngest patient being fourteen. Nineteen of the twenty-eight have occurred in women and nine in men. The rupture usually occurs from three weeks to three months following the fracture.

The pathogenesis of this condition has been subject to controversy. However, there has been no preexisting condition, either of a general or local nature, found in the histories or examinations of these patients to account for the rupture. Hence, it must be assumed that the tendon is so injured at the time of the fracture that rupture subsequently takes place.

Kleinschmidt, in attempting to account for the rupture, first thought there might be a preexisting tendon disease predisposing to the rupture, but this has not been substantiated. Later, however, he carried out a number of experiments on cadavera in which he produced what he termed the typical radius fracture, by extending the hand and thumb and delivering a hard blow to the flexed elbow. In each of these he found a small tear in the extensor pollicis longus tendon, or its sheath, from a sharp fragment of the fracture.

Weigeldt and Hauck each have described the rupture as due to a tearing of the mesotendon at the time of fracture, with a disturbance of blood supply, resulting in necrosis of the tendon fibers and rupture. Lülsdorf reported a case following a fracture with no displacement, and explained the rupture as a result of necrosis from disturbance of blood supply. Axhausen explains the rupture as a result of continual rubbing of the tendon on the sharp bone edges at the fracture site, with a gradual fraying out of the tendon. This, however, does not offer sufficient explanation, for, if this were true, there should be a larger number of late tendon ruptures, since many displaced Colles' fractures are incompletely reduced or not reduced at all.

Scudder states that the extensor tendon may easily be caught by adhesions and that spontaneous rupture may occur a number of weeks later. DaCosta recognizes the possibility of late spontaneous rupture of the extensor pollicis longus tendon, after Colles' fracture, but offers no explanation for its occurrence. Ashhurst reported a case in which the extensor tendon had become densely adherent in the callus, the tendon later rupturing as a result of a strain on it during a strong grasping movement. The proximal end remained attached in the dense callus and the distal end was pulled away.

After reviewing the reported cases and studying this one and the dissected wrists of cadavera, two explanations for late rupture of the extensor pollicis longus tendon following Colles' fracture have been considered:

First, a direct partial severance of the tendon by a sharp edge of bone at the time of fracture, which, not being completely healed during the period of immobilization, leaves a weakened spot and then later a strong exertion upon the tendon causes it to rupture. No case was found reported of complete rupture of the tendon at the time the fracture occurred. It is not difficult to understand how the extensor tendon to the thumb could be injured by a sharp fragment of bone, as it is placed in intimate contact to the radius in the radial groove and is held tightly to the bone by the dense non-yielding transverse carpal ligament. Hence, with the tendon taut, as it is at the time of fracture, a sharp edge of bone projecting posteriorly could partly sever the tendon, the latter being caught between the fracture edge and the transverse carpal ligament. Then, following the period of immobilization, during which the laceration is not sufficiently repaired, a strong exertion upon the tendon causes it to rupture at the weakened spot. This explanation holds in the writer's case and would appear to be the most rational one for the majority of the reported cases, since only a few at the time of operation have revealed other conditions sufficient to account for the rupture. In fact, there is no way of knowing that this condition of partial tendon severance does not occur more frequently with healing of the defect during the period of immobilization and before any severe strain is placed upon the tendon.

Another explanation is considered, as a few of the reported cases of late rupture have occurred following fracture in which there has been little or no displacement of the fracture fragment as in the case reported by Lülsdorf. A possible cause of rupture in these cases is a local tendon necrosis from a disturbance of blood supply, produced by rupturing of the blood vessels in and around the taut tendon at the time of fracture, with the added pressure of the hematoma, or later the callus, to further obstruct the blood supply. Later the tendon may become adherent to the surrounding structures resulting from the hematoma and the callus. With the tendon thus weakened and adherent to surrounding structures, a strong grasping effort, following immobilization, might cause the tendon to separate. Ashhurst described the possibility of the tendon becoming adherent to surrounding structures in the case he reported.

Various immediate causes of late rupture of the extensor pollicis longus tendon have been reported, such as inserting hair pins, peeling apples, making buttonholes, handling dishes, and more strenuous exertions,—as chopping wood.

The only symptom common to all these patients has been the inability to extend the thumb, although a few have stated they felt a "snapping" or "giving way of something" on the back of the wrist. There has been no associated pain with the rupture. On examination there is inability to extend the thumb; the separated tendon ends may be palpated; and there is

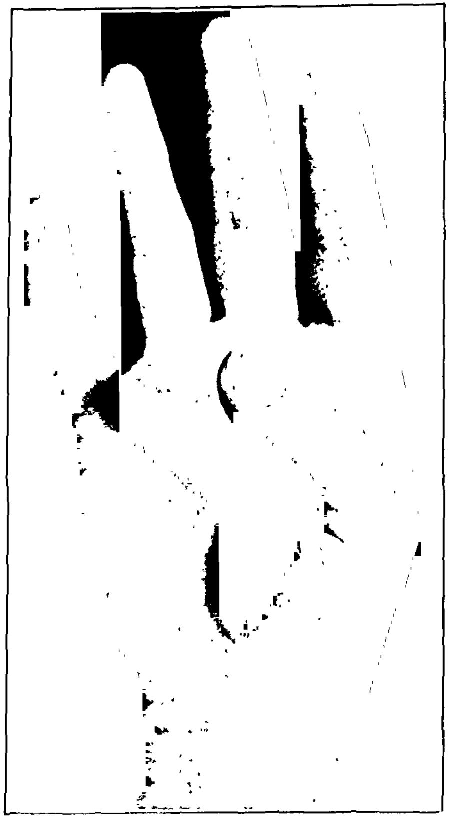

Fig. 1

Case 1. Thumb in position of flexion with inability to extend it, due to late rupture of extensor pollicis longus tendon following Colles' fracture.

Fig. 2

Case 1. Colles' fracture with displacement of small fragment of cortex posteriorly, causing late rupture of extensor pollicis longus tendon.

Fig. 3

Case 1. Thumb extended after restoration of function in extensor pollicis longus tendon, following tendon suture eight months previously.

an obliteration of the "snuff-box" from absence of the ulnar-bounding tendon. The diagnosis is easily made on the history and findings.

Treatment is surgical and consists of suturing the divided tendon ends. This may be done with the tendon lying in its normal groove beneath the transverse carpal ligament, or subcutaneously when this is impossible. Failure to approximate the separated tendon ends can be overcome by using some form of tenoplasty. The thumb should be immobilized in a position of extension to release all tension on the tendon, for a period of three to four weeks. Resulting stiffness, if present, is overcome with guarded movements, physiotherapy, and massage.

CASE REPORT

Late rupture of extensor pollicis longus tendon following Colles' fracture: Female, aged thirty-five, was admitted to the University of Chicago Clinics, April 21, 1930, having received a right Colles' fracture in a fall, on March 2, 1930. X-ray pictures revealed a small bony fragment with a posterior displacement. The wrist was kept immobilized for a period of three weeks after the fracture. Following this period the patient was able to extend the thumb, although she used it very little. Then, on April 1, 1930, while using her right hand to insert a hair pin, she suddenly noticed that she could not extend the right thumb. There was no pain, sensation remained intact, and all other motions of thumb, fingers, and wrist were normal.

On examination the right thumb was flexed and the patient was unable to extend it, although all other motions were intact (Fig. 1). There was an obliteration of the "snuff-box", due to absence of the ulnar-bounding tendon. Tendon ends could not be palpated and sensations were normal. A roentgenogram (Fig. 2) shows a small bony fragment displaced posteriorly. Diagnosis of late rupture of the extensor pollicis longus tendon following Colles' fracture was made. At operation, April 22, 1930, under local anaesthesia, the tendon ends were found divided over a sharp prominence on the back of the radius. The ends were somewhat retracted and frayed out, although neither was bound down by adhesions. It was impossible to approximate them beneath the transverse carpal ligament so that they were approximated and sutured with silk subcutaneously. A cast was applied to the hand, forearm, and arm, with the thumb and wrist extended and the elbow flexed. It was removed after three weeks and active motion started gradually. Improvement was steady and three months later the patient had approximately fifty per cent. of normal function. On examination eleven months after the operation, extension of the thumb was normal and all other movements were normal except for slight limitation of flexion of the metacarpophalangeal joint (Fig. 2).

Rupture of the flexor pollicis longus tendon following Colles' fracture, which condition was not found reported in the literature, should be much less likely of occurrence than late rupture of the extensor tendon to the thumb, because of anatomical reasons. The flexor tendon is not in as intimate contact with the radius as the extensor tendon, being separated by the pronator quadratus muscle, except at the distal part of the bone, where it lies in close contact to it. In the case reported here the flexor tendon was found divided at a sharp angulation of the fracture on the volar surface of the radius. Following the period of immobilization, the patient was able to flex the distal phalanx of the thumb, but used the hand very cautiously. Then, three months after the fracture, while chopping wood—the first strenuous work attempted following the fracture—the tendon ruptured. The

explanation for this rupture was a partial severance of the tendon from the sharp fracture fragment at the time of injury, which failed to heal completely. Then, later, during strenuous work, the tendon ruptured at the weakened spot.

CASE REPORT

Late rupture of flexor pollicis longus tendon following Colles' fracture: Male, aged thirty-five, entered the University of Chicago Clinics, April 4, 1929, having received a right Colles' fracture four months previously while cranking a tractor. A large swelling developed on the volar surface of the wrist, but the skin remained intact. X-ray pictures at that time revealed a marked dorsal displacement of the lower fragment. The fracture was reduced, and a splint worn for four weeks. He gradually regained use of the wrist and thumb and apparently was on the road to recovery when three months after the accident, while chopping wood, he suddenly noticed that he could not flex the right thumb. There was no pain. Five weeks after the loss of this motion he came to the Clinic and, on examination, flexion of the distal phalanx of the thumb was absent; however, all other motions were present and sensations were intact. The tendon ends could not be palpated. A roentgenogram (Fig. 4) showed the radius to be fractured transversely near the wrist joint. Diagnosis of late rupture of the flexor pollicis longus tendon following Colles' fracture was made. At operation the flexor tendon was found divided at the level of a prominence on the volar surface of the radius, resulting from the fracture. The retracted proximal end was found and isolated from adhesions. The distal end was so markedly retracted that it could not be found and drawn out of its sheath. A small incision was then made over the front of the first phalanx of the thumb and the tendon isolated. After a hard pull on the proximal end, the adhesions gave way and the tendon was brought out of the wound. A tendon carrier was then passed from the upper wound along the tendon sheath and out through the lower incision. The end of the tendon was sutured to it and drawn upward through the sheath. With the thumb and wrist in flexion, the two ends were sutured with chronic catgut, the wounds closed and a cast was applied to the hand, forearm, and arm with the thumb, wrist, and elbow in flexion. The cast was left on for four weeks after which the patient gradually increased the use of the hand. Figure 5 shows the degree of flexion and of extension possible twenty months after operation. He reported that he had a very useful hand and that the grip on tools with the thumb was practically normal.

FIG. 4

Case 2. Fracture of radius which caused late rupture of the flexor pollicis longus tendon.

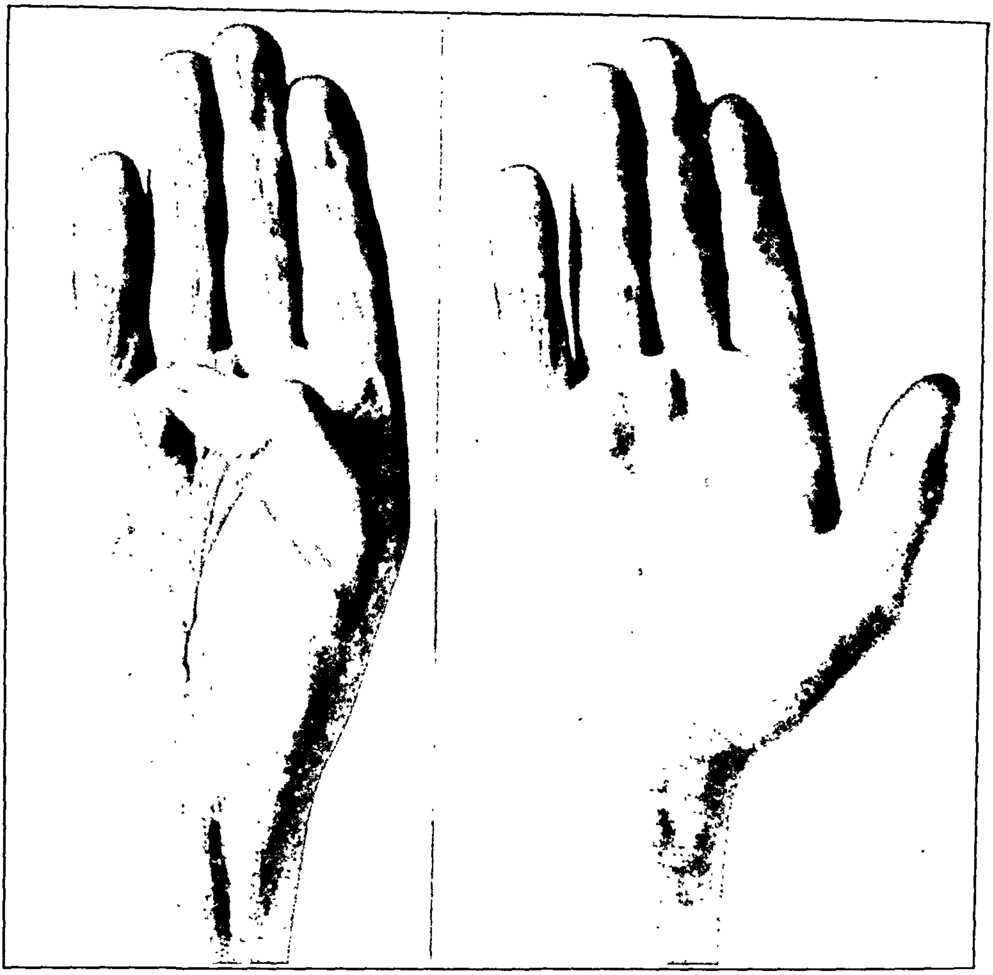

FIG. 5

Case 2. Degree of flexion and extension possible in thumb twenty months after suturing separated ends of flexor pollicis longus tendon.

SUMMARY

1. Wrist tendon ruptures occur following disease processes and trauma, single or multiple.
2. A case of late rupture of the extensor pollicis longus tendon following Colles' fracture is reported, making twenty-eight in the literature.
3. A case of late rupture of the flexor pollicis longus tendon following Colles' fracture is reported. No other reported cases were found.
4. Almost complete restoration of function followed suture of the tendon in each case.

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AN EXPERIMENTAL STUDY OF THE DISTRIBUTION OF THE PERIPHERAL BLOOD FLOW*

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The purpose of this paper is to discuss the results obtained in an experimental study undertaken to determine the manner of the distribution of the blood flow in the posterior extremities of the dog and to what extent it was affected by some of the factors which would seem obviously most influential. No attempt will be made to describe in detail any of the experiments undertaken, but the experimental methods employed will be briefly summarized.

In all experiments change of temperature of tissues was the criterion of change in the volume flow of circulation. Only comparatively rapid changes in the tissues were interpreted as a measure of volume flow of circulation. For example, if the temperature of the foot of the experimental animal is found to remain at thirty degrees, centigrade, during a period in which the temperature of the circulating fluid in the femoral artery is maintained at thirty-nine degrees, and the temperature of the foot changes promptly to correspond with a change in the temperature of the circulating fluid in the femoral artery, it would seem that it were certain that the fluid was flowing through the vascular bed of the foot. On the other hand, if the temperature of the experimental animal's foot remained at approximately room temperature (twenty degrees, centigrade) during a period in which the temperature of the circulating fluid entering the posterior extremity was forty degrees, centigrade, or did not show prompt change in temperature to correspond with relatively gross changes in the temperature of the fluid in the femoral artery, it is obvious that very little or none of the fluid is passing through the vascular bed of the foot.

In one series of experiments the following method was employed. A dog was anaesthetized with morphin and ether. Cannulae were placed in the right carotid and right femoral arteries and the blood pressures in these vessels were recorded with mercury manometers and a kymograph. Mercury thermometers were imbedded in the left foot, left thigh, and rectum. The temperatures of these sites were recorded every five minutes. The abdomen was opened and the aorta carefully isolated sufficiently to apply a screw clamp, which made it possible to constrict the terminal aorta to any desired extent without disturbing the continuity of the experiment.

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The results obtained in this series of experiments were quite different. In some experiments the temperatures of the foot, thigh, and rectum were always depressed by constricting the aorta and quickly rose if the constriction were released. In other experiments alternate obstruction and release of the aorta would cause changes in temperature in the rectum and thigh, but none in the foot. In some instances the temperature of the foot would change relatively more than that of the thigh. In other experiments alternate obstruction and release of obstruction of the aorta would not cause any perceptible change in temperature of the thigh or foot.

In the experiments in which constriction of the aorta caused no temperature changes in the extremity, it was observed that the blood pressure changes in the femoral artery associated with occlusion of the aorta were different from those associated with occlusion of the aorta in those experiments in which tissue temperature changes followed constriction of the aorta. In the former it was impossible to produce a slowly progressive fall in the femoral arterial pressure by slowly occluding the aorta, while in the latter instances gradual occlusion of the aorta was accompanied by a corresponding slow decline in femoral arterial pressure. If constriction of the aorta caused no tissue temperature changes, then during its gradual constriction the femoral arterial pressure was not perceptibly depressed until all evidences of pulse pressure had been obliterated and the aorta was almost totally occluded. Completion of the occlusion of the aorta caused a sharp drop in femoral arterial pressure. If constriction of the aorta did result in marked tissue temperature changes, then with slow constriction of the aorta there was a correspondingly slow depression of femoral arterial pressure and the pulse pressure waves remained in the tracing of the femoral arterial pressure until a low level was reached. From the application of the known principles of lateral pressure in a tube, it would seem as if it must be true that in those experiments in which constriction of the aorta was not associated with tissue temperature changes, there was really very little stream motion in the column of blood in this vessel. In other words, normal blood pressure and normal pulsation in an artery is not a reliable index of the volume flow of blood through this vessel. From these and other experiments we are convinced that a tissue may contain normally pulsating arteries with very little volume flow of blood.

These experiments emphasize the fact that the peripheral blood flow is very unequally distributed to the tissues. We have tried by various methods to influence this unequal distribution of blood, either to change it to a homogenous distribution or to shift the inequalities. Without going into details of these methods it will suffice to say here that the only method which has so far been found effective during the comparatively brief time which any such experiment may be continued is by making use of the vasomotor nervous mechanism. It would seem as if the problem influencing the distribution of the peripheral blood flow would be well on the way to being solved, if it were possible to devise some method of inducing at will the flow of blood through the foot of an experimental animal at

a time when for no apparent reason this part of the body is devoid of any perceptible circulation.

A series of experiments has also been carried out in which the circulation of the posterior extremities of the dog has been maintained by a perfusion pump. Here it is worth while calling attention to the fact that in these experiments, in which the circulation is produced by a perfusion pump, we are dealing with conditions entirely different from those existing in a living animal. The most important differences in the conditions are:—first, the output of the perfusion pump can be accurately controlled; second, the circulating fluid can never be made even closely to simulate normal circulating blood; and, third, the extremities are separated from any influence exerted by the central nervous system or sympathetic ganglia.

The fact that the experimentator has perfect control of the output of the perfusion pump is of course of tremendous importance in the study of the effects of arterial obstruction. In a living animal, obstruction of an artery is always attended by changes which operate to compensate for the obstruction. Since these compensatory changes cannot be controlled, the investigator has no accurate knowledge of how much change he is making in the volume flow of blood through any portion of the body by varying degrees of obstruction of the primary artery supplying this particular portion of the body. If constriction of an artery influenced the cardiac output, it might even happen that partial obstruction of an artery would increase the volume flow of blood in the tissue supplied by this artery. Also, it has been found that a large artery with good pulsation and normal intravascular pressure, which was presumably transmitting a good stream of blood, was in reality nothing more than a pulsating streamless column of fluid. The mechanism of automatic readjustment of the circulation of blood is so extremely complex that it is difficult or impossible to isolate for study any of the various factors concerned. At the present time, therefore, the only accurate method of securing the known output of fluid supplied to any part of the peripheral circulation is by the use of a perfusion pump. The perfusion pump devised by Dale has been used in all of our experiments. This pump is so constructed that the circulating fluid comes in contact with only glass and rubber. The output of the pump can be accurately determined and changed at any time without interrupting in any way the continuity of the experiment. The pump is also equipped for maintaining a constant temperature of the fluid to be perfused, and this temperature may be easily and quickly changed if desired.

The most serious objection to the assumption that changes in the circulation of a living animal produced by some particular cause would be the same as those observed to follow the influence of this particular factor in an experiment in which the circulation was maintained artificially by a perfusion pump, is the fact that it is impossible to maintain the "normal" characteristics of the circulating fluid. In our experiments we have used defibrinated blood, artificial blood made from gum acacia, Ringer's solution, and physiological salt solution. In the experiments in

which blood was used as the perfusion fluid, a satisfactory method was devised of keeping a relatively normal state of oxygen and carbon-dioxid content. In some of the experiments the oxygen consumption was fairly satisfactorily determined. No satisfactory means has as yet been devised of maintaining normal hydrogen-ion concentration. Also, it is obvious that the products of tissue metabolism accumulate in the perfused fluid, and the perfused fluid is probably relatively quickly depleted of the products of any of the glands of internal secretion.

The description of the details of any of the experiments performed will be omitted and only a few of the more important results obtained will be discussed. In each experiment the animal was deeply anaesthetized, bled to death, and the posterior half of the body was separated as rapidly as possible. The blood was defibrinated and used as the perfusion fluid in some experiments. The aorta and the inferior vena cava were connected with the perfusion pump. The lateral pressure and "pulse rate" and pulse pressure in the aorta were recorded with a mercury manometer and kymograph. Mercury thermometers were imbedded in the rectum, thigh, and foot. Thermometers were also placed in the cannulae so as to record the temperature of inflowing and outflowing perfusion fluid. The capacity of the perfusion pump had been carefully calibrated so that the exact amount of its output was recorded. The weight of the posterior half of the body was recorded at frequent intervals. In the experiments in which blood was used as the perfusion fluid, special equipment was included to furnish oxygen and remove carbon dioxid.

The experiments in which the perfusion pump was used were particularly useful in determining the effect of changes in the temperature of the perfusion fluid on the temperature of the tissues of the extremity. In some experiments changes in temperature of the inflowing fluid were followed immediately by corresponding changes in the temperatures of the rectum, thigh, and foot. In other experiments, in spite of gross changes in the temperature of the perfusion fluid, the temperature of the foot would remain stationary or show a change in the opposite direction to that of the change in temperature of the perfused fluid. In other instances the foot seemed to respond more quickly than the thigh.

The results obtained from changing the output of the perfusion pump during a period in which the temperature of the perfusion fluid was kept constant were of particular interest. It was found that changing the output of the pump usually did not influence the distribution of the circulation. If the volume flow of the fluid was increased, it appeared that all of it passed through much the same parts of the extremity which had received the previous smaller volume flow. In other words, it was impossible to force a wider or more homogenous distribution of blood flow by increasing the total amount of volume flow. It was found in some instances that the output of the pump could be increased to an amount certainly in excess of the normal volume flow to the posterior extremities and still apparently have all of the fluid flowing through only that portion

of the vascular bed near the cannulae. In these experiments the muscles of the extremities retained the power of contraction on stimulation and the blood vessels reacted to adrenalin.

The effect of alteration of venous pressure was studied. In general any change in venous pressure was followed by a nearly identical corresponding change in arterial pressure. In this the perfusion experiment differs sharply from the experiments on the living animal. Increasing venous pressure in the living only affects arterial pressure which has already been reduced by arterial obstruction and, as has been previously shown, reduces the volume flow of blood. In the perfusion experiments there was no arterial obstruction and the output of the pump was not changed by increasing or diminishing the peripheral resistance. Usually increasing venous pressure did appreciably change the distribution of the blood flow in the perfusion experiments. In some instances it seemed possible, so to speak, to open a portion of the vascular bed for circulation by increasing venous pressure.

In general it seemed that the experiments with the perfusion pump gave an opportunity for studying the purely mechanical factors of the peripheral blood flow more or less independent of the influence of the vasomotor nerve mechanism. It was interesting to find that, with the extremities in a state of "rest", much the same conditions existed as in the living animals, as far as being able to bring about artificial influence was concerned. The blood flow was unequally distributed and this distribution could not be appreciably changed by any method used.

The experiments briefly described in this paper have been included to illustrate the experimental methods used and to call attention to a few fundamental principles involved in the mechanism of the distribution of the peripheral blood flow. It is not our intention to produce the impression that any of these principles have not been previously recognized, but to discuss the application of certain of these fundamental principles to an analysis of conditions present in abnormal states of the circulation.

The regulation of the circulation is an extremely complex mechanism. The cardiac output, the cross-section area of the entire circulatory bed, the capacity of the circulatory bed of any particular portion of the body, the blood volume, the chemical characteristics of the blood, and the balance existing between the inflow and outflow of blood from all or any particular portion of the body, are factors which are constantly varying through relatively wide limits. Of all the known characteristics of the blood and the blood vascular system, there are only two which apparently remain comparatively constant,—the chemical constitution of arterial blood and the intravascular pressure in the large arteries.

In discussing the distribution of the peripheral circulation, the fact that the blood pressure in the abdominal aorta remains so remarkably constant is of great importance. This fact is emphasized in all of our experiments in which the abdominal aorta was wholly or partially occluded. Occlusion of so large an artery so near the left ventricle must produce an

enormous change in relative cross section area of the circulatory bed and would, therefore, be expected to produce a marked change in the blood pressure proximal to the constriction. As a matter of fact, there is but a slight momentary change and the heart and the unobstructed circulatory system adjust conditions so as to retain a "normal" pressure in the base of the aorta.

With a constant blood pressure the volume flow of blood through any particular portion of the body—as, for example, an extremity—is necessarily dependent on the total cross-section area of the smallest portion of the circulatory bed of the extremity. If all the communications between the arteries and veins were the same size and offered the same resistance, the flow of blood would be homogenously distributed. As a matter of fact, however, this is just the condition which is not present in the "normal" state. For example, Blalock has shown that during contraction of a muscle the flow of blood is not only completely stopped, but also that the blood already in the arterioles is actually forced back in the artery supplying the muscles. The experiments described in this paper show that it is possible to have a large volume flow of blood through the extremities with certain portions of these extremities having no evidence of any blood flowing through. It is worth repeating that this condition may be present with good pulsation in the arteries actually in the area devoid of demonstrable blood flow.

It follows therefore that peripheral blood flow is not homogenously distributed and we wish to discuss particularly the factors which influence this unequal distribution.

The actual amount of blood which flows through any particular channel connecting an artery and a vein is obviously dependent on difference in intravascular pressure between the artery and the vein and the size of the channel. In health the arterial pressure remains remarkably constant. The size of the channel is known to be influenced by the vasomotor nerves. The phenomenon of opening and closing of capillaries has been clearly demonstrated by Krogh. The venous pressure is influenced by the massaging action of muscle contraction with the action of valves of the veins. The fact that hydrostatic pressure must influence distribution of blood must be accepted. The volume flow of blood in any particular area must therefore be determined by the influence of the vasomotor mechanism and by mechanical conditions not associated with vasomotor phenomena. In the normal individual the influence of the vasomotor mechanism undoubtedly predominates, and there is, so to speak, constantly changing irregular or unhomogenous blood flow which is normal. In fact it has been pointed out in a previous communication that an actively irregular and changing distribution of peripheral blood is a characteristic of the normal state. The static, regular, unchanging distribution of peripheral blood flow is abnormal.

The capacity of the vasomotor mechanism to regulate the peripheral circulation is seemingly adapted to certain limits of total blood flow and

capacity of the blood vessels, and, if the conditions are such as to be without this limit, then the vasomotor mechanism becomes inadequate or inefficient and the influence of mechanical factors, not a part of the vasomotor mechanism, predominates.

This idea is suggested in comparing the results obtained in experiments in which the total volume flow of blood through the posterior extremities was varied by partial occlusion of the aorta with those obtained by perfusion of the posterior extremities which had been completely severed from the central and sympathetic nervous systems. The temperature fluctuations in the tissues which resulted from changing the temperature of the inflowing fluid and the output of the pump were usually those which would be expected from the nature of the mechanical changes. With compression of the aorta the effect could not be predicted. In other words, the circulatory bed without vasomotor control behaves similar to a system of lifeless tubes. Also it is well known in clinical medicine that an extremity in which there is marked arterial obstruction shows very marked effects of changes in simple mechanical conditions. It becomes bloodless on elevation and engorged with blood if depressed. The well known curative effect of elevation of the extremity with varicose ulcers is another example of the application of the influence of pure mechanics on the distribution of blood flow. In several instances of sudden arterial occlusion we have felt convinced that the vitality of the extremities has been preserved for periods of one to three days by frequently alternating elevation and depression.

The regulation of the peripheral blood flow is an extremely complex mechanism even if isolated from the complex mechanism of the action of the heart. Although in last analysis blood flow is a purely mechanical process, the mechanism of control is extremely complex. It is influenced by nerves and hormones, but is also influenced by purely mechanical factors. With marked abnormalities, consideration of these mechanical factors may become important. There has been a great deal of study of the problems of total blood flow. The distribution of the blood flow in peripheral circulatory bed has not been extensively studied. Attempts to "*improve the circulation of the extremity*" undoubtedly involves more than an attempt to influence the total amount of volume flow of blood delivered to or returned from this extremity.

THE EFFECT OF INSULIN ON THE HEALING OF EXPERIMENTAL FRACTURES IN THE RABBIT*†

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The utilization of insulin to attempt to accelerate the rate of healing of fractured bones has received scant attention so far. For several years it has been known that the local and general application of insulin to diabetic and non-diabetic ulcers has stimulated healing, has hastened the proliferation of epithelium, and has produced early cicatrization of wounds [1,2,6,10,13,19]. It has also been noted, over and over again, that injections of insulin into animals affect markedly the metabolism of calcium and phosphorus. Hence, this experiment was undertaken in the hope that a practical clinical application might be discovered whereby insulin could be used in combating the growing problem presented by delayed union of fractures. I was aware, however, that the employment by other observers of many chemical and glandular substances, known to alter the concentration of calcium and phosphorus in the blood, had failed to accelerate appreciably the healing of fractures. Injection of parathormone[15], administration of irradiated ergosterol [12,14,17,21,23], or feeding of calcium or phosphorus[9,18,22], or both, have not produced tangible increase in the formation of callus or in the rate of healing of bone.

METHOD

In my experiment, normal adult laboratory rabbits, which averaged two and four-tenths kilograms in weight, were used. Males and females were about equal in number. All animals received the normal laboratory diet, which contains adequate amounts of all required food factors. Open osteotomy of the left fibula, by standard method, was performed on all. Under ether anaesthesia, and with the usual aseptic precautions, an anterolateral incision was made in the left leg, the upper third of the fibula was exposed, and the bone was fractured by twisting it with a hemostat. The wound was then sutured in layers, and a collodion dressing applied. This type of fracture was selected because, in the rabbit, the fibula is fused distally with the tibia for more than half its length and proximally it is firmly united with the head of the tibia by the interosseous ligament (Fig. 1). Thus, it was possible to produce a uniform type of fracture, there was a minimal chance of displacement and of motion, and external splinting was not necessary.

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†Abstract of thesis submitted to the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Master of Science in Orthopaedic Surgery.

FIG. 1

Rabbit's leg twenty-six days after operation. The relative shortness of the fibula in this animal, its secure attachments proximally and distally, and the type of fracture which was performed in this experiment are evident.

The operation was performed on fifteen normal rabbits used as controls, two of which died from the anaesthetic at operation, and two others died of intercurrent disease in the course of the experiment. The remaining animals were killed at intervals varying from nine to sixty-two days after operation. The relatively low mortality—as experiments on rabbits go—probably was due to the absence of external splints and to the minimal injury to tissue involved in the operation.

Fifteen similar animals were operated on in identically the same way and their subsequent care was the same, except for the injections of insulin. In this second group, daily intravenous injection of insulin, in the lateral vein of the ear, was commenced immediately after operation. Iletin was used, and the animals received one and five-tenths units for each kilogram of body weight daily at about two in the afternoon. None of the animals died at operation; five died from reactions to insulin in the course of the experiment. The remainder were killed at intervals corresponding to those at which the control animals were killed.

At first, roentgenologic examination of the fractured bone of representative animals from the control group and from the group receiving insulin was made weekly. This method was later abandoned, however, because there was no detectable difference in the progress of healing between the animals of the two groups. Microscopic studies were undertaken as the animals died or were killed. Bone from the site of fracture was decalcified in hydrochloric acid (4 per cent.), sectioned, and stained with hematoxylin and eosin; then comparisons were made in the rate of healing of bone from animals in the two groups.

RESULTS

In the majority of cases, comparison between the sections, taken through the fractures at similar periods of time after operation, of the normal control rabbits and of those which had received daily injections of insulin, revealed a tendency to more advanced healing in the insulinized

Fig. 2

Fracture in normal animal twenty-three days after operation. In the line of fracture at *a* there is considerable osteoid callus between the medullary canals. At *b* there is a very slight amount of provisional callus in which there is beginning calcification. This should be compared with Fig. 3. (× 50)

Fig. 3

Fracture in insulinized animal twenty-four days after operation. In the line of fracture at *a* there is almost complete calcification between the trabeculae of the medullary canals. No osteoid tissue is present. This should be compared with Fig. 2. (× 40)

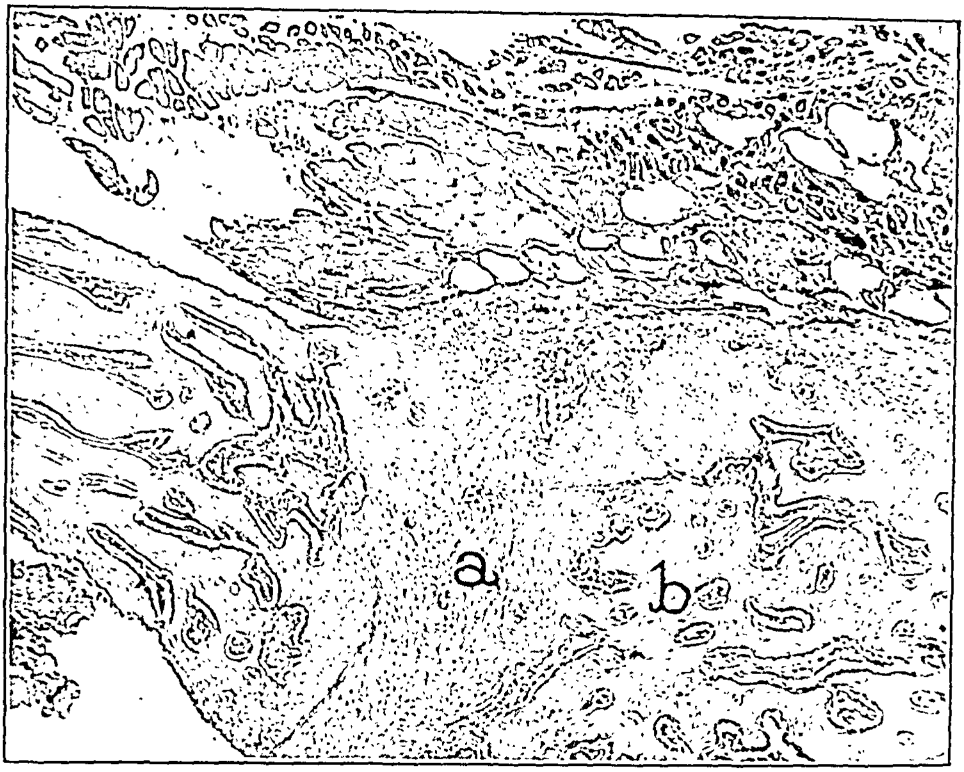

Fig. 4

Fracture in normal animal thirty-three days after operation. In the line of fracture at *a*, there is calcification of transverse callus with regression of chondroblasts. Occasional osteoid cells are seen at the margin of the medullary bone (*b*) and callus. This should be compared with Fig. 5. (× 40)

animals. The steps in the process (hemorrhage, reorganization of the clot, proliferation of osteoblasts, calcification, and so forth) seemed to be identical in the two groups, and the amount of reaction between the ends of the bone seemed to be the same. But the process of healing seemed to be relatively more advanced in the insulinized animals in relation to the time after operation.

For instance, Figure 2 represents a specimen from a normal animal twenty-three days after the fracture. At the line of fracture (*a*), there is moderate amount of osteoid callus between the medullary canals of the ends of bone; calcification has begun but has not progressed markedly. At *b*, the subperiosteal provisional callus is calcified and there is beginning regression of the chondroblasts.

On the other hand, in Figure 3, which represents a specimen from an animal that received insulin twenty-four days after operation, there is total absence of osteoid callus between the ends of bone. Apparently the calcification at the line of fracture (*a*) has passed the osteoid stage and the rearrangement of trabeculae is now ready to begin. There is no obvious difference between the type of bone in these two healing fractures, and the only difference seems to be in the progress of the process of healing.

Considering the material from another angle, it was found that by selecting sections from each group which seemed to be at similar stages of

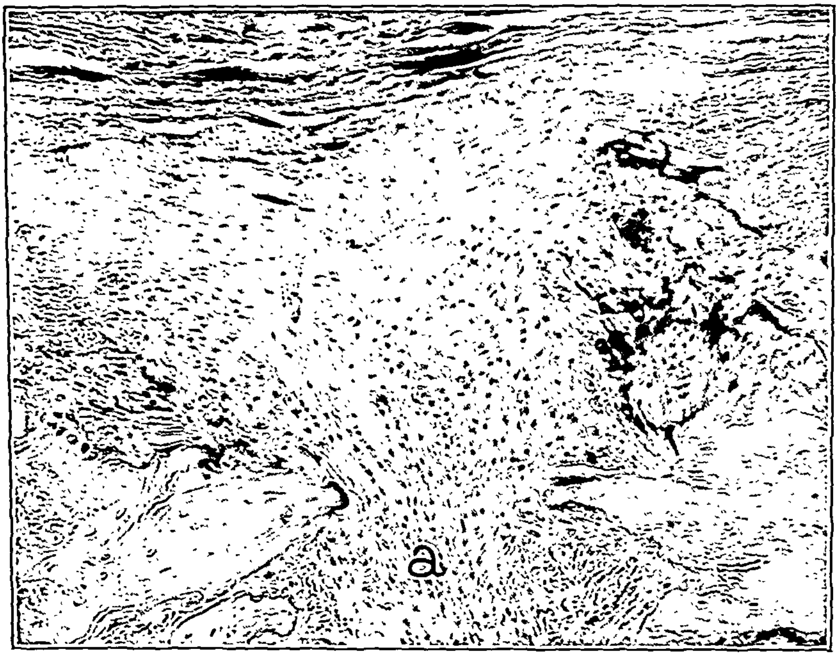

FIG. 5

Fracture in insulinized animal twenty-two days after operation. In the fracture line at *a*, there is almost complete calcification of intramedullary callus. The ends of bone are firmly united. This should be compared with Fig. 4. (× 70)

healing, the difference in time after operation between the normal control animals and those which had received insulin was even more marked. The sections in Figures 4 and 5 seem to be identical so far as healing is concerned. In each, the calcification of osteoid callus is complete, except for the presence of a few scattered chondroblasts near the juncture of the normal medullary bone, and the new calcified callus. In each of these two sections retraction of the subperiosteal provisional callus is the same. In neither is there any evidence of beginning rearrangement of the trabeculae to assume the normal longitudinal arrangement. Yet Figure 4 represents fracture in a normal control animal thirty-three days after the operation and Figure 5 represents fracture in the insulinized animal twenty-two days after operation.

In those fractures examined two weeks or less after operation, the difference in progress of healing was very slight, and, if there was any precocity, it occurred consistently in the insulinized animals. Likewise, after four weeks, the final stages of healing in the two groups of animals seemed little different. In other words, the variations in the progress of healing, slight though they were, were detectable only in the group of animals which were killed in the second to the fourth week after operation. And this difference, which was entirely microscopic, was principally manifest as earlier calcification of callus in the insulinized animals. It was not possible to determine the relative solidity of bony union in the two groups, but to all appearances, gross and microscopic, it was identical.

COMMENT AND SUMMARY

In the year that insulin was isolated, Fiske first called attention to the decreased output of urinary phosphates after ingestion of sugar by normal persons. Blatherwick, Bell, and Hill administered insulin to normal persons and noted that there was marked decrease in the inorganic phosphorus content of the blood plasma. The same phenomenon was observed in rabbits by Wigglesworth and his coworkers, and in normal dogs by Briggs, Koechig, Doisy, and Weber. In addition to the constant observation of a lowered value for blood phosphates after injection of insulin, many observers have noted a concomitant rise in the value for serum calcium. Davies injected insulin into rabbits and found a marked rise in concentration of serum calcium. Brougher found elevation of blood calcium for a period of two and a half hours in normal and parathyroidectomized dogs, and Ellsworth also noted that administration of glucose and insulin to human beings caused reduction for two to four hours in the value for blood phosphorus and a rise in the value for total blood calcium.

The only previous study of the possible relationship between insulin metabolism and the growth of bone was performed by Schazillo and Ksendsowsky in 1928. They fractured the legs of rats and administered to them non-toxic doses of insulin and calcium chlorid. They estimated the rate of healing by the density of the roentgenologic shadow, and, by this rather gross means of observation, they felt that they could demonstrate a more intense formation of callus at the site of fracture of insulinized animals.

In my experiment with fracture of the fibula in the rabbit, calcification of the callus between fourteen and twenty-eight days after operation seemed to be slightly more advanced in those animals which received daily injections of insulin than in the control animals. This difference was not detectable grossly; yet it was definite when the site of fracture was examined microscopically.

Recently, Leriche and Policard, in their monograph on physiology of bone, have outlined the healing of fractures as an essentially local process involving local vascular changes and redistribution of calcium. My work seems to confirm the conclusion of these investigators; it apparently has no clinical application.

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A DIAGNOSTIC SIGN IN EXAMINATION OF AFFECTIONS OF THE SACRO-ILIAC JOINT; CHAIR TEST

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The following clinical test is suggested as an examination for sacro-iliac conditions, particularly when there is a question of injury or the actual existence of pathology.

The patient, who is standing before an ordinary chair firmly held, with the surgeon extending the hand for the patient to grasp, is asked to step up into the chair. It is surprising how many patients accomplish this act with the attention centered on the up-stepping leg which naturally seems to be the one in which the examiner is interested. With the direction then to step down, the surgeon, still holding the hand, exercises a slight push through the forearm so that the patient steps down unexpectedly, producing a very slight jar which is transmitted upward through the weight-receiving extremity. The surgeon then changes his hand upon the chair and extends the other, repeating the procedure with the opposite leg of the patient.

The test has several interesting features. Patients who are uncooperative in many tests seem to have an interest in this. The chair being large and firm gives a sense of security and the aid given by the surgeon's hand adds to the feeling of confidence. Practically all patients can accomplish this effort and, without instructions, the patient invariably puts the best foot forward, which means he steps up with the leg which has the best hip joint, the best psoas, or the best glutei. Further, the patient's attention is concentrated on the up-stepping leg and without attention to the after-coming extremity.

In this test, when the patient stands upon one foot, the muscles of the leg and the thigh are engaged in maintaining balance. The abductors and extensors of the hip joint (the glutei and the hamstrings), inasmuch as their insertions are fixed and their origins are movable, act very powerfully in this reverse direction to fix the pelvis in respect to the femur and even incline it somewhat so as to bring the center of gravity nearer to the weight-bearing hip. The spine assumes a balancing scoliosis position, convex toward the weight-bearing side, which is accomplished in part by the opposite psoas which is acting to flex the opposite thigh. Since the Y-ligament is a sufficient antagonist for the glutei, the psoas on the weight-bearing side is comparatively relaxed.

In this position, all the weight of the body, including that of the opposite lower extremity, is transmitted to the weight-bearing leg through the sacro-iliac joint on the weight-bearing side. It is under such conditions that only minimal, if any, musculature is available as a protective medium to the ligaments of the sacro-iliac joint.

Until the up-stepping foot is placed upon the chair, the weight-bearing sacro-iliac joint is under condition of pressure and of sheer. This sheering stress is greatest when the pelvis is nearest to the horizontal plane, and lessens with corresponding increase of the factor of pressure the more the pelvis is inclined, for this position makes the weight-bearing more direct from the sacrum to the ilium. The muscles of the up-stepping extremity are at a complete disadvantage, and, before they can be of assistance, a definite upward push must be made by the weight-bearing leg. When the push occurs, considerable inertia of the body is overcome, but not without definite pulsion of the ilium upward, increasing the sacro-iliac sheer. Until the after-coming foot has risen several inches from the floor, the up-stepping extremity has done no real propulsive work, but is in the status of recovery in readiness for the effort. It then assumes all the work and the relaxed after-coming extremity returns to its usual hemi-weight-bearing function and the sacro-iliac joint is then relieved of the unusual mechanical stress.

If the patient steps down with the foot which was last placed in the chair, the weight is received by that extremity with a slight but definite shock, which increases the sheering stress of the sacro-iliac joint on that side,—a down-coming shock, wholly passive, whereas the up-going one is due to muscular effort.

With *bona fide* joint trouble, the patient can hardly be expected to perform this test without complaint. If the surgeon will keep in mind the above outlined physiological mechanisms, he will discover that the sacro-iliac malingerer will step down hard on the foot of the "affected side" without pain.

THE USE OF AUSCULTATORY PERCUSSION FOR THE EXAMINATION OF FRACTURES

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In certain fractures, auscultatory percussion may be employed as a rapid, painless, and always available indicator of the relative position of the fragments and, at a later period, as a method of determining the extent of bony consolidation. This test is of utility chiefly in fractures of the shaft of the femur, humerus, and clavicle to supplement roentgen-ray examination, as a substitute for it when x-ray facilities are unavailable, and to replace it when x-ray and fluoroscopy are inadequate or inapplicable. Conditions such as the latter are common,—particularly in the treatment of femoral-shaft fractures; so that, even in the proximity of complete x-ray equipment, auscultatory percussion can render great assistance to the fracture surgeon.

A search of the literature reveals only the most cursory application of sound phenomena to the examination of fractures. Stewart's surgical textbook mentions that, if one end of a fractured bone is percussed and a stethoscope applied to the other, the sound may fail to come through.[1] In discussing fracture diagnosis, Stimson writes, "Auscultatory percussion, the stethoscope being moved from one fragment to the other while percussion is made upon the first, will sometimes give a marked change in the sound as the line of fracture is crossed; but it is rarely significant, except in cases in which the diagnosis can be made by other means".[2] I have been able to discover no further development in the interpretation or application of the method.

If auscultatory percussion is applied across two bony prominences separated by a long bone, the sound heard through the stethoscope has a characteristic "osteal" quality and is loud, high-pitched, and moderately resonant. While to some extent this sound is modified by body structures in the neighborhood of the examined area, the osteal quality always predominates and is directly attributable to the vibration of the bone in response to the percussion impact. Its loud volume is due to the excellent transmission of sound waves by the bony structure*.

*It is possible to demonstrate the remarkable sound conduction through the skeleton by applying a tuning fork over some bony prominence of the body, a stethoscope at a remote point where the skeleton is superficial, and comparing the volume of the auscultated sound with that obtained when the instruments are applied the same distance apart over deep soft tissue. The striking difference in conduction properties so elicited indicates that when auscultatory percussion is applied from one bony prominence to another, the course of the sound waves lies chiefly through the intervening bone, and only in small part through the soft tissue.

The sound lost on crossing normal articulations is small in amount. This may be demonstrated by comparing the sound elicited by auscultatory percussion through a joint—such as the hip or knee—, which is ankylosed by bone, with that through the opposite normal joint. While easily detectable, the difference in volume is not as marked as might be expected.

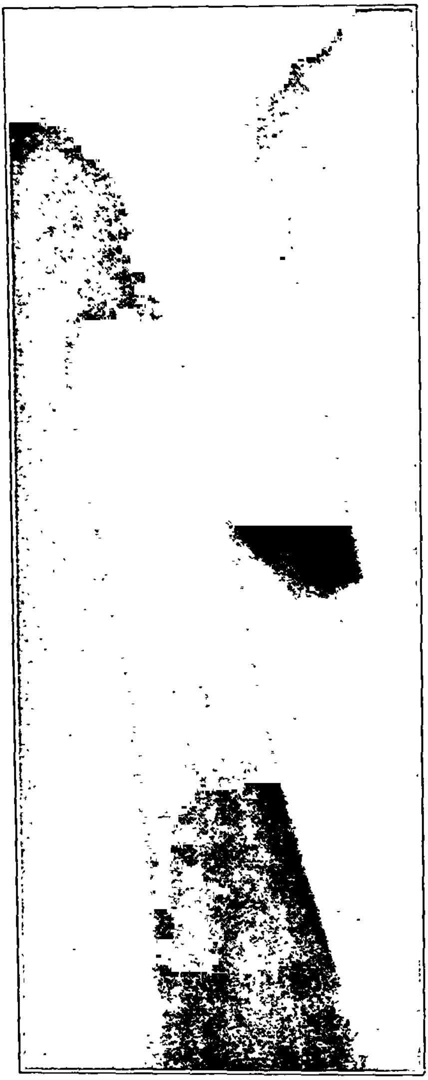

FIG. 1-A.

FIG. 1-B.

Case 1 of four, successive femoral-shaft fractures in the reduction of which auscultatory percussion assisted in securing end-to-end apposition.

FIG. 1-A Case 1. On admission. FIG. 1-B Case 1. After reduction.

A fracture lying between the percussed area and the stethoscope produces a change in the character of this sound which is readily perceptible by comparison with that elicited over corresponding points on the normal side. This change, which may be described in terms of intensity, quality, and pitch, constitutes the criterion of the test.

The change in sound character caused by fracture depends upon two distinct and separate mechanisms. Primarily, the quality and pitch of the note produced by the original impact is altered. Percussion of an intact bone causes it to vibrate with a frequency and character corresponding to

its elastic properties as a solid unit. Each fragment of a fractured bone, on receiving the stimulus, vibrates as a separate unit. Owing to its smaller size and altered shape compared with that of the intact bone, the frequency and character of the vibrations are correspondingly changed and a different sound produced. Generally, this sound is less resonant, of indeterminable pitch, and approximates that heard over soft tissue. Secondarily, the conduction of this sound through the bone shaft to the place where the stethoscope is applied may be blocked at the site of fracture and the audible volume so diminished. This diminution varies with the relative position of the fragments. If there is perfect position, the sound waves are transmitted across the fracture almost as well as across normal bone. If slight

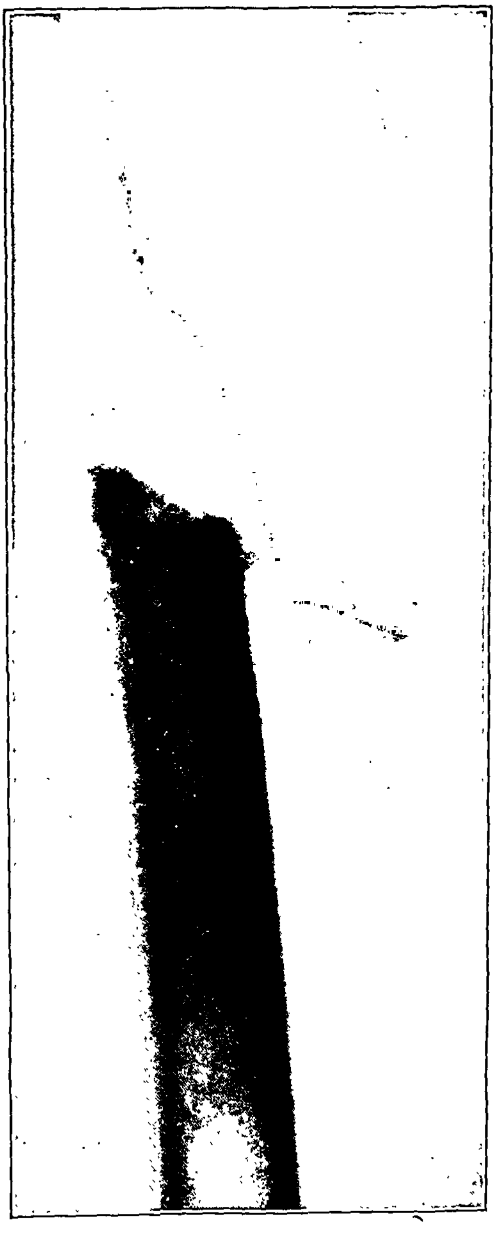

FIG. 2-A
Case 2. On admission.

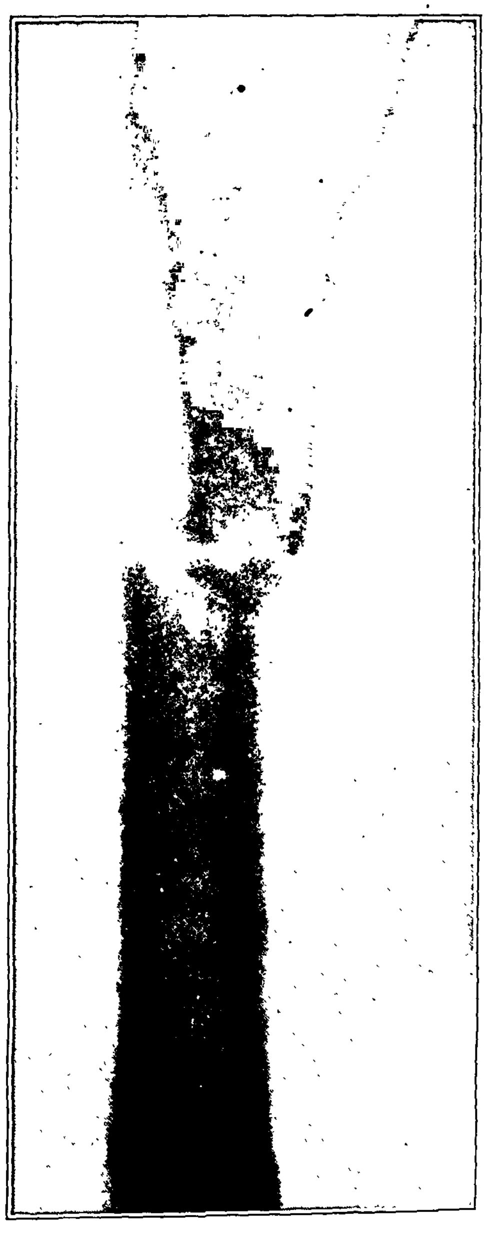

FIG. 2-B
Case 2. After reduction.

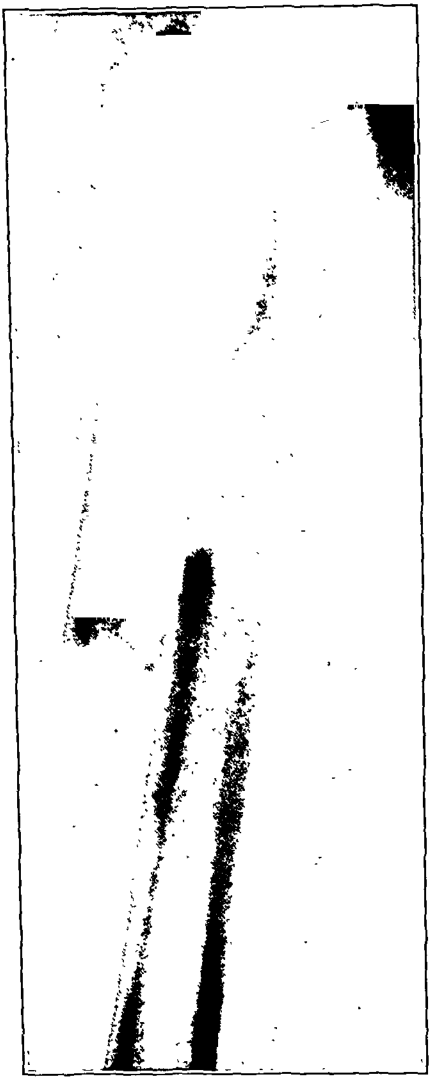

Fig. 3-A
Case 3. On admission.

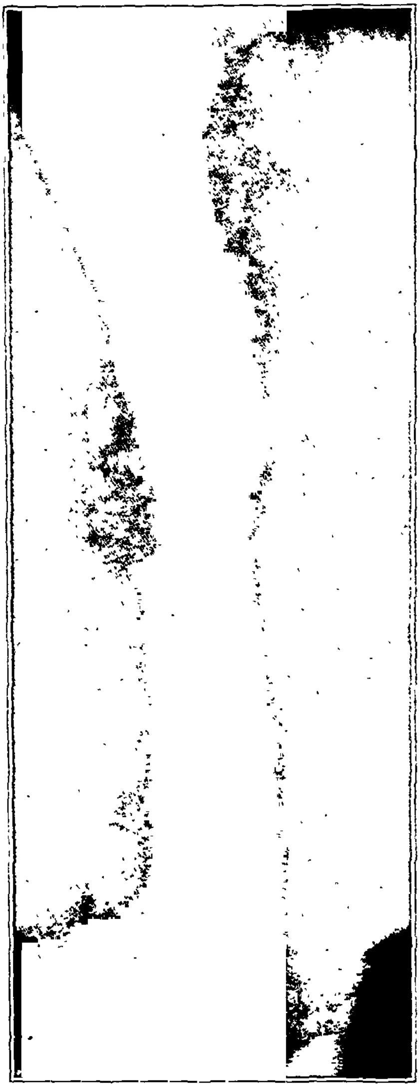

Fig. 3-B
Case 3. After reduction.

displacement is present, but end-to-end contact persists, more sound will be lost due to the inability of the waves to cross the fracture site in their entirety. Entire absence of end-to-end contact entails practically complete loss of sound transmission, due to reflection of the waves as they pass through media of different density.† Overriding with side-to-side contact effects practically as complete an obstruction to sound as does wide separation between the fragments. In general, it may be emphasized that pitch and quality changes are dependent upon the free vibration of each separate

†"Sound waves may be reflected backward toward the direction from which they came. This is especially apt to occur when vibrations pass through tissues of different densities." (See Bibliography[7].)

fragment. These changes may be detected following complete fractures, regardless of the position of the fragments, and they persist until union is firm. On the other hand, diminution of sound intensity depends solely upon poor conduction through the fracture area. It is not appreciable unless end-to-end contact is absent.

The clarity with which these phenomena may be elicited varies with the location and the type of the fracture. The femur, humerus, and clavicle, which constitute single osseous connecting links, are best adapted to examination of this character. It is feasible to examine the double-boned forearm and leg by auscultatory percussion, but the two bony sound paths available may cause difficulty in determining to which bone the acoustic signs refer. Such examination is seldom of clinical value, unless x-ray facilities are not at hand. Auscultatory percussion of the small long bones of the hand and foot rarely yields satisfactory results. The fracture to be

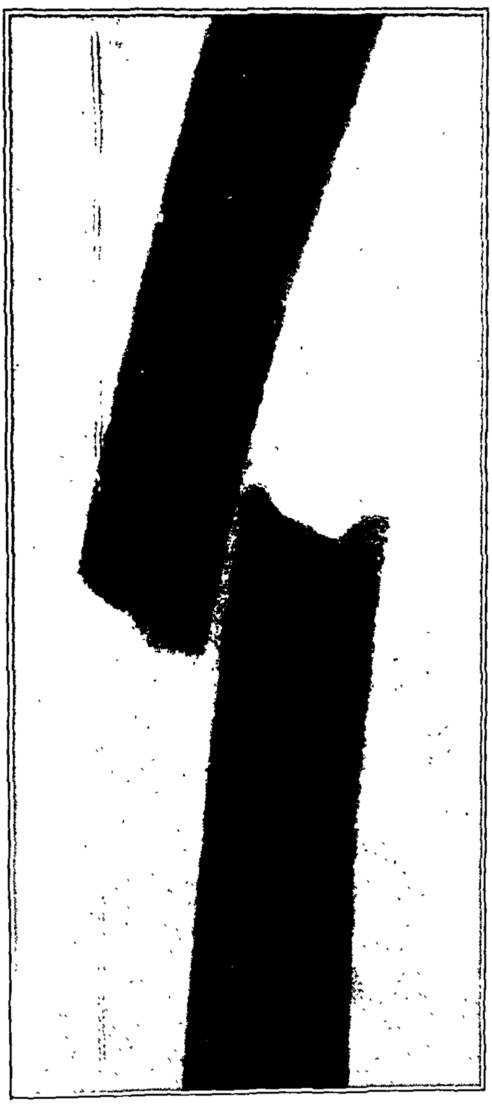

FIG. 4-A
Case 4. On admission.

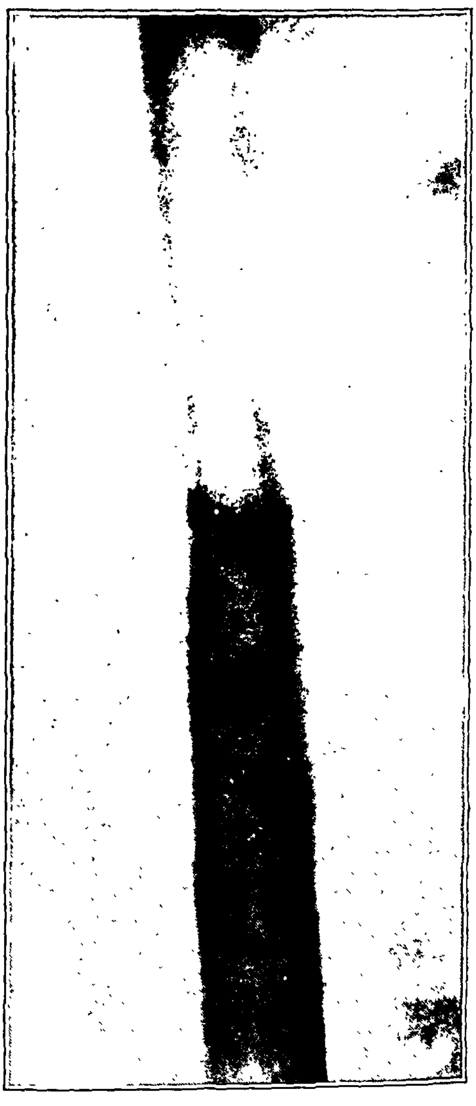

FIG. 4-B
Case 4. After reduction.

examined must lie between superficial bony points and must be complete. As a rule, green-stick, incomplete split, and firmly impacted fractures will not furnish acoustic evidence of their presence. Badly comminuted fractures will conduct sound best when in best position, but, even then, the volume is hardly comparable with that obtained through normal bone.

The technique of examination is extremely simple and requires little explanation. The percussion impact should be light but sufficiently strong to produce a clear distinct note on the normal side, and the stethoscope bell should be small so that it can be accurately applied over irregular surfaces. Convenient prominences for auscultation and percussion may be chosen even though joints lie in the sound path. Passage through normal joints does not cause any material alteration in sound quality, and the small decrease in sound volume is similarly manifested between corresponding points on the normal side. For example, when the humerus is examined, the olecranon may be percussed and the stethoscope applied over the acromion. The femur may be examined from the patella to the anterior-superior spine of the ilium and the clavicle from its acrominal end to the sternum. If more direct comparison between both sides is desired, the stethoscope bell may be centrally applied over the sternum (for the humerus), and over the pubes (for the femur), and held there by an assistant, so that both hands of the examiner are free for alternate bilateral percussion.

In suitable cases, auscultatory percussion may be employed for the purpose of diagnosis, as a guide in the process of reduction, as a sign to detect subsequent "slipping", and eventually, as a test of healing.

As an aid in diagnosis, the test is valuable because it furnishes a painless and rapid means of determining whether the suspected fracture is complete and whether the fragments are in end-to-end contact. Even in the superficial clavicle, hematoma and tenderness at the site of injury cause difficulty in ascertaining these facts by inspection and palpation. Alteration in pitch and quality of the note elicited by auscultatory percussion denotes complete fracture. If the intensity is not appreciably decreased, it may be immediately assumed that end-to-end contact is present and that any apparent deformity is due to angulation or hematoma. Decrease of intensity signifies displacement. With the help of this information, so easily and rapidly obtainable, treatment often may be expedited.

The employment of auscultatory percussion to guide fracture reduction is of greatest value in fractures of the shaft of the femur, because the depth of the overlying tissue in this area precludes palpation of the bone. In these circumstances, quality and pitch changes are neglected, and relative sound intensity serves as the only important criterion. When the fragment ends abut each other, sound transmission is good and becomes increasingly better as perfect position is approached. Exigencies of the individual case, as well as the variety of treatment methods in current use for such fractures, would render valueless the enunciation of any universal routine examination procedure. The test may be equally well employed with fracture table and with any manner of Balkan frame technique and, if correctly interpreted,

can serve to indicate immediately whether or not the fracture has been reduced.

As an indicator of "slipping", the test is especially helpful in femoral shaft fractures, and may be daily applied as a routine measure during the first few weeks of the postoperative course. Decrease in sound intensity elicited during this time by auscultatory percussion signifies loss of good position or "slipping". When the injured member is encased in plaster, two one-inch holes cut directly over the anterior-superior spine and the patella will not interfere with immobilization and will provide sufficient access for percussion and auscultation. The plaster will not affect bony sound conduction, if care is taken to prevent it from touching the percussing finger and stethoscope bell during the examination.

Progress in the development of bony union may be tested by applying the same technique at greater intervals during the postoperative course. Normally, the sound character observed after reduction gradually improves, so that, when consolidation is complete, it is indistinguishable from that elicited on the opposite side,—even when the fracture has healed with some

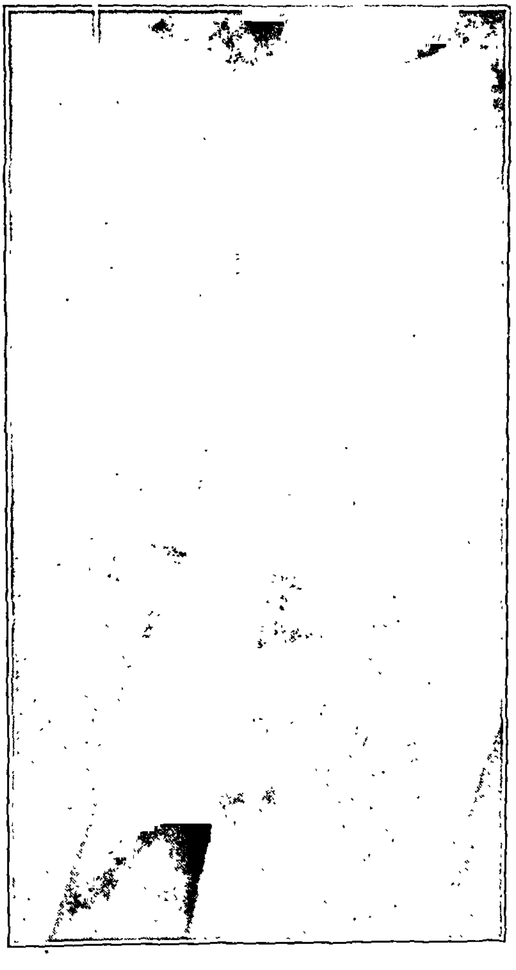

Fig. 5-A

Equivocal x-ray after two months of immobilization. Auscultatory percussion applied at this time indicated that union was incomplete.

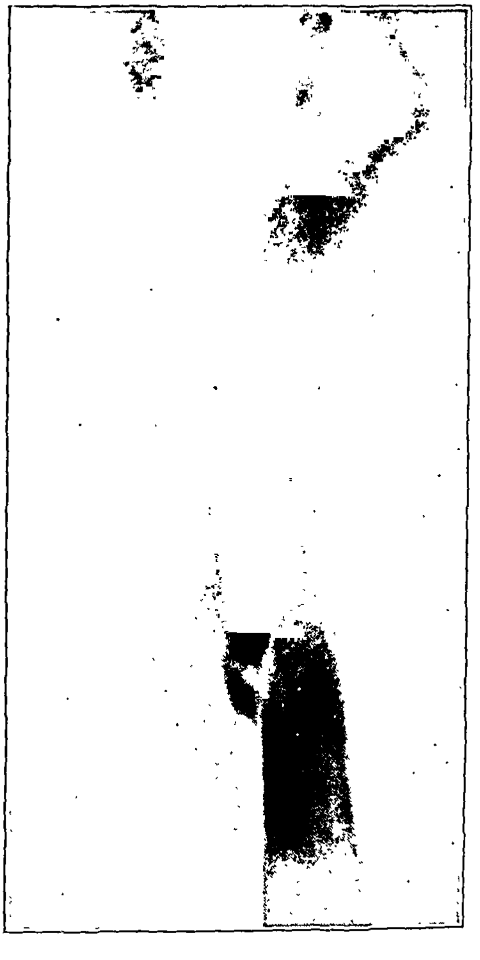

Fig. 5-B

Incomplete union demonstrated by x-ray two and one-half weeks later, after attempted weight-bearing.

overriding or angulation. Persistence of perceptible alteration in pitch, quality, or intensity signifies incomplete consolidation. Whether a negligible degree of union can transmit sound waves as well as normal bone remains to be determined. One of the femoral shaft fractures examined by this method resulted in delayed union despite excellent position. After two months of immobilization, x-ray evidence was equivocal (Fig. 5-A). Clinically, the femur appeared solid and capable of weight-bearing. The true condition, however, was suspected by the alteration in the pitch and quality of the transmitted sound and was clinically demonstrated several weeks later by pain, angulation, and false motion after a short time of weight-bearing (Fig. 5-B). Further experiences of this nature must be awaited.

SUMMARY AND CONCLUSIONS

Auscultatory percussion applied across fractures of the shaft of the femur, humerus, and clavicle may be so interpreted as to indicate the presence of a complete fracture, the relative position of the fragments, and, during the postoperative course, the development of bony union. The stethoscope bell and the percussing finger should be applied over bony prominences on either side of the fracture and the sound so elicited compared with that produced by the same procedure on the normal side. Sound alteration constitutes the criterion of the test. Pitch and quality changes result from free vibration of the separate fragments and, accordingly, signify complete fracture or incomplete union. Appreciable diminution in sound intensity indicates poor conduction and reflects absence of end-to-end contact. The chief merits of the examination method may be summarized as follows:

1. The application of the test is simple, rapid, and entails no discomfort to the patient.
2. The desired information is immediately obtainable.
3. For diagnostic purposes, the test is always available when x-ray facilities are not at hand.
4. In the hospital, it may be employed equally well with the patient on the orthopaedic table, in traction apparatus, in bed, or in a plaster cast, and is consequently applicable during, as well as following, the reduction.
5. For certain purposes, the method appears more accurate than x-ray or fluoroscopy.
   - *A*. The presence of end-to-end contact may be established with certainty by auscultatory percussion whereas, with x-ray, the true displacement often appears magnified or reduced. (Distortion due to oblique exposure.)
   - *B*. Determination of the degree of bony union attained is sometimes difficult with x-ray, particularly when plaster or overabundant callus obscures the fracture area. Auscultatory percussion is in no way affected by these factors.

A diversity of other orthopaedic measures entails the sometimes difficult task of determining the presence of bony contact or bony joint fusion. In general, when the test is applied in such cases, its interpretation will follow the above outlined basic principles. The practical utility of the method in this field is being studied at the present time.

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SURGICAL APPROACH IN OLD POSTERIOR DISLOCATION OF THE ELBOW

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Old posterior dislocation of the elbow joint is a common surgical condition in China. Due to the lack of hospitals and modern surgical methods, patients suffering from the condition often go untreated while others come under the care of Chinese barbers—long recognized as the official bone-setters of the country—or are treated by local native practitioners with various kinds of splinting, massage, or manipulation that are not only ineffective but often harmful. As a result, these patients eventually arrive at the hospital clinic with badly traumatized stiffened arms that are locked in a position either of complete extension—since this is the cosmetic position of choice among the Chinese laity—or with the affected elbow held at an obtuse angle with only a few degrees of residual motion.

The clinical picture is usually unmistakable, the only question being one of possible associated fracture. In cases of long standing without concomitant fracture, the x-ray often shows the formation of callus along the posterior surface of the lower end of the humerus where the periosteum has been separated from the cortex. This same condition may be present along the anterior aspect of the dislocated joint, but is more rare.

The reduction of these old dislocations by operation is, of course, clearly indicated, the closed method being reserved as a rule for cases of less than three weeks' standing. Much harm can be done by forced manipulation of these dislocated joints, and the exercise of brute force in attempting reduction is to be condemned. The ideal method of treating these old dislocations of the elbow is the one that will secure reduction with the least amount of trauma, and with the surest guaranty of maximum function. It was with this aim in view that the operative procedure here described was devised.

The operation was first performed by the writer in the Peking Union Medical College Hospital, China, in 1926, and subsequently upon five Chinese patients whose case reports are appended. The short series of cases was unfortunately concluded because of the writer's return to America.

TECHNIQUE OF THE OPERATION

With the elbow flexed over the patient's chest, a posterior median incision is made from the tip of the olecranon proximally for a distance of five inches. The skin and subcutaneous tissues are divided, exposing the lower end of the triceps muscle and its tendon. Hemostasis is carefully observed.

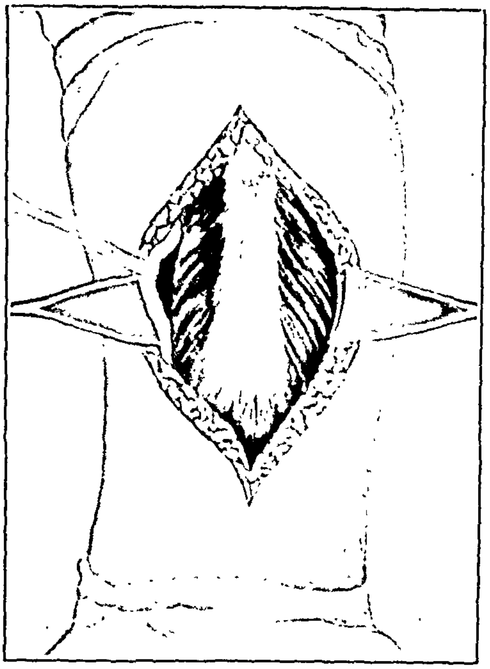


FIG. 1

Posterior skin incision, exposing the lower end of the triceps muscle and tendon. The ulnar nerve has been isolated and is being gently retracted by a saline-moistened tape.

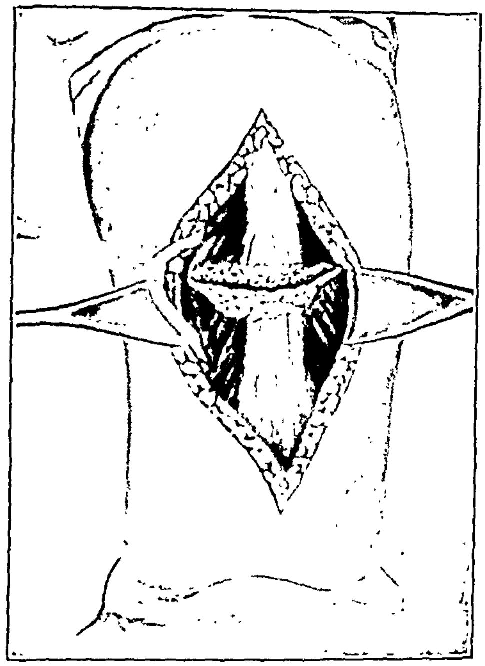


FIG. 2

Division of the triceps tendon with its lateral muscular expansions at a level one-half inch above the tip of the olecranon.

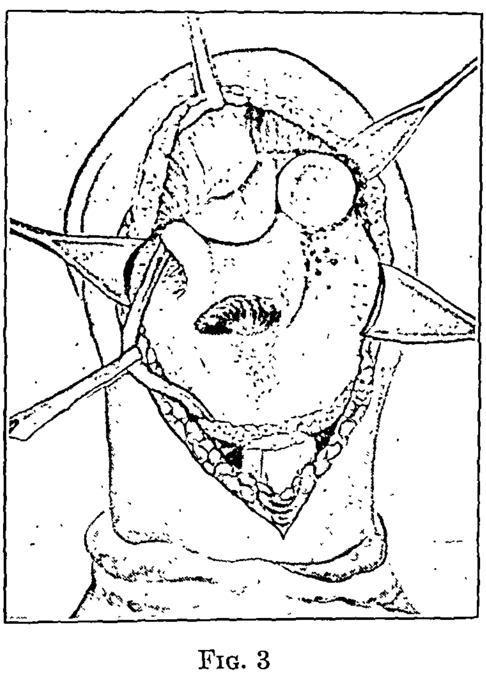


FIG. 3

Exposure of the flexed dislocated joint posteriorly. Callus, fibrous tissue, and adhesions have been carefully removed without traumatizing the articular surfaces. Reduction of the dislocation can now be readily accomplished.

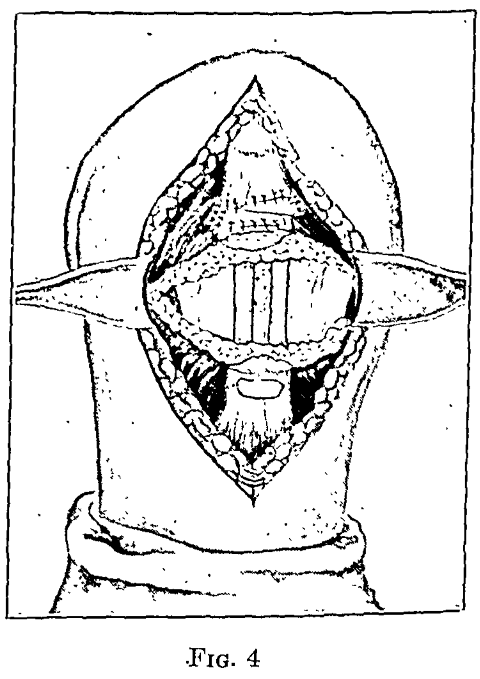


FIG. 4

A strong strip of tendon or fascia lata is sewed through the cut ends of the triceps tendon, elongating it, as required, and acting not only as a connecting link, but as a living graft.

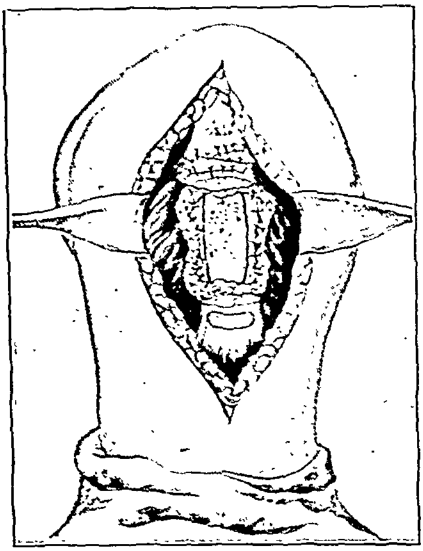


FIG. 5
The triceps muscle expansions are first approximated to the tendon transplant.

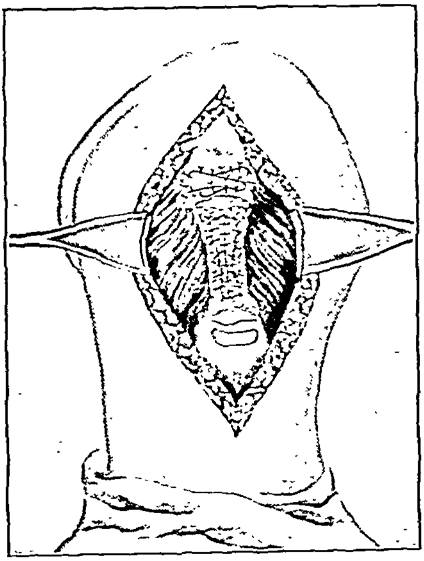


FIG. 6
The two strands of transplanted tendon or fascia lata are then sewed together in the mid-line.

The ulnar nerve is then exposed and gently retracted from the wound by means of a saline-moistened tape (Fig. 1). The triceps tendon with its lateral muscular expansions is next divided transversely by one sweep of the knife at a point one-half inch above the olecranon tip (Fig. 2). This opens up the space containing fibrous and scar tissue, torn capsule, organized hematoma, callus, and new bone, all of which must be carefully removed without damaging the normal bone structures. Especial care is taken not to injure the articular surfaces of the humerus, radius, and ulna. After all of the joint structures have been well defined posteriorly, the forearm is gently flexed, bringing into view whatever adhesions are present, and these, as well as any resistant structures, are divided as the forearm is gradually brought into acute flexion (Fig. 3).

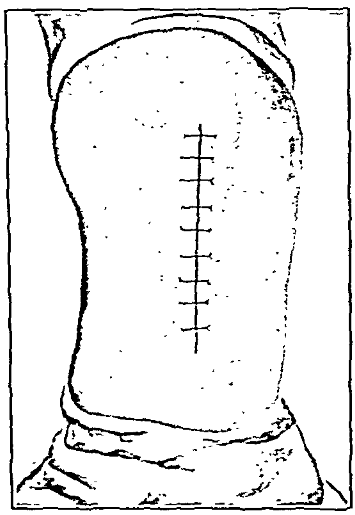


FIG. 7
Closure of the wound while the arm is held in a right-angle position.

Having freed the dislocated joint of all adhesions, any lateral displacement is now remedied, before the usual classical reduction manipulation is carried out. This is performed without force or injury to cartilaginous surfaces, particular care being taken to protect the coronoid process of the ulna. There should be no forceful stretching or levering of structures and no tearing of soft parts. If reduction is not easy upon the first attempt,

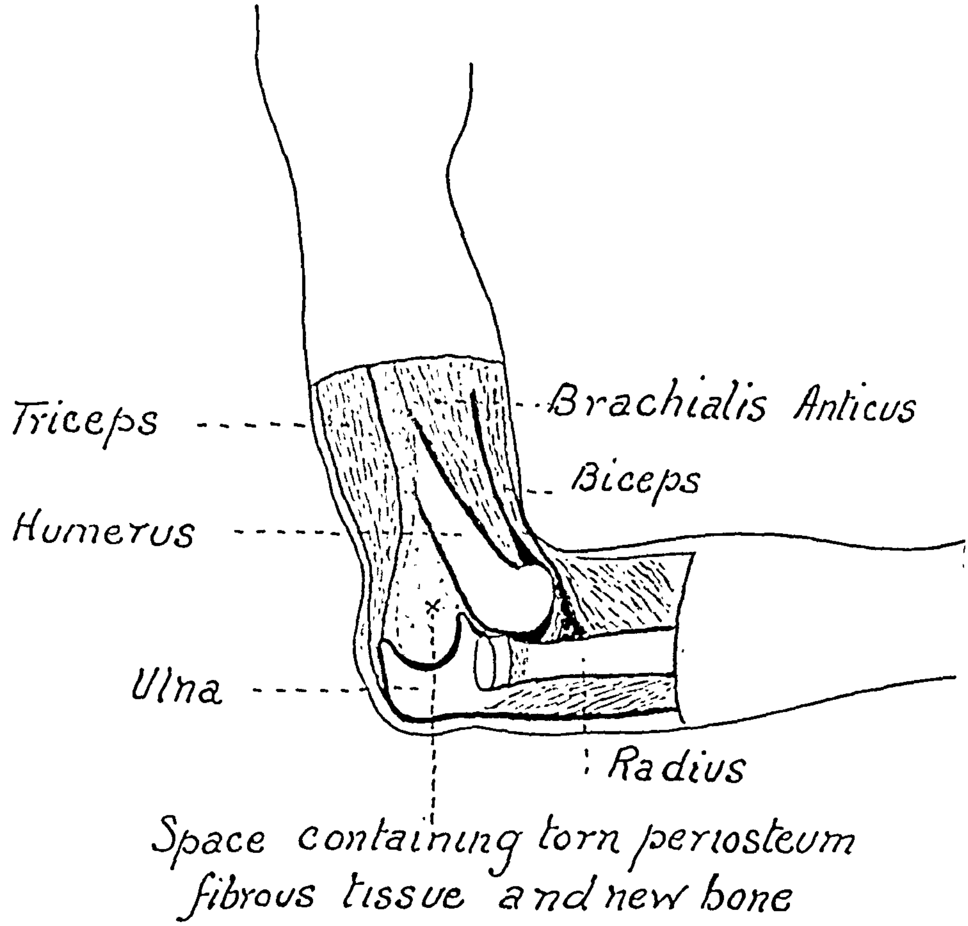


FIG. 8

Diagram of posterior dislocation of the elbow to show the space where new bone forms and acts as an obstacle to reduction.

the joint should again be gently carried through its full range of motion and those structures producing any obstruction be carefully divided. Patience and gentleness at this stage of the operation are imperative and if practiced will result in success.

Following reduction, either a portion of the tendo achillis is removed or a strong strip of fascia lata is obtained from the patient's thigh. This material is then employed as a connecting link between the divided triceps tendon ends (Fig. 4) and remains *in situ* as a living graft. To it the triceps muscle expansions are approximated (Fig. 5), after which the two strands of tendon or fascia are sewed together in the mid-line (Fig. 6). During the suture of the transplanted tendon, with silk, the forearm is held in the right-angle position and remains so during the closure of the wound which is performed without tension in the usual way (Fig. 7). A light molded plaster slab is used as a splint. This is applied over the anterior aspect of the arm, the elbow being held in a position of seventy to ninety degrees of flexion.

POSTOPERATIVE CARE

Stitches are removed on the tenth day and the plaster shell discarded at the end of two weeks. Gentle motions are then started and a Jones collar-

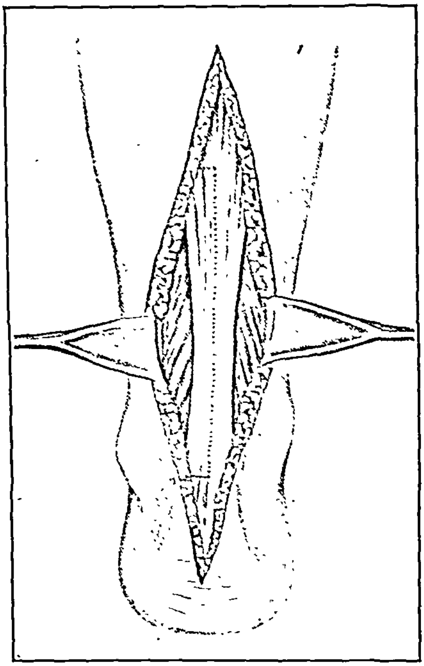


Fig. 9

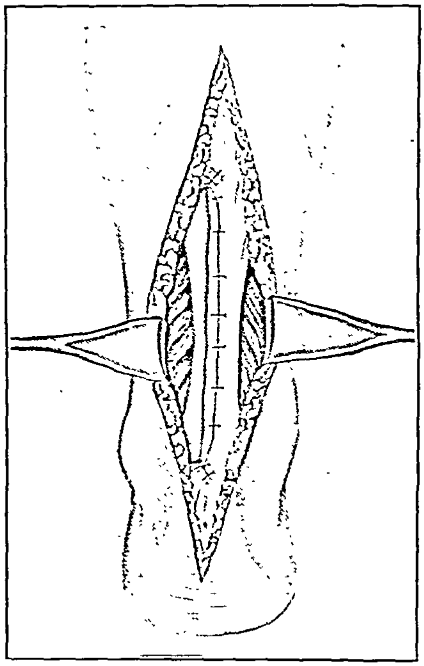


Fig. 10

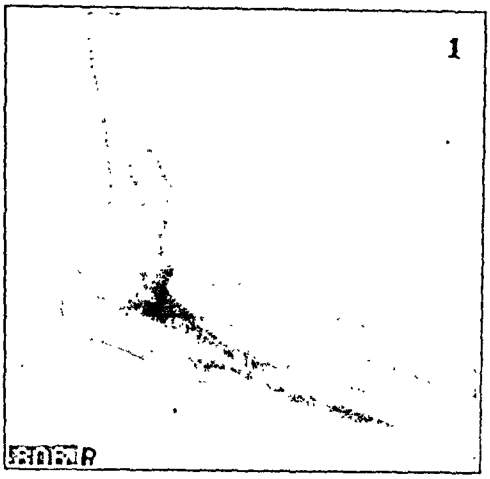
Diagram illustrating the use of a portion of the tendo achillis if desired as a graft for the triceps tendon. In the series of cases here presented, fascia lata was found to be equally successful as a transplant.

and-cuff sling applied. This sling holds the forearm in a position of acute flexion, where it remains constantly for another two weeks, except at times of exercises which are given twice daily. These exercises consist in very slowly and gently extending the arm and then directing it through as wide a range of motion as possible, but always stopping at the point of acute pain and never forcing the joint.

At the end of this two weeks' period of gentle exercises, which is one month after the operation, the Jones collar-and-cuff sling is used only at night to retain the position of acute flexion, while during the day the arm is given complete freedom. Physiotherapy, consisting of baking, massage, and active and passive motions, is now employed daily and continued for as long a period as required. Should the joint stiffen or "shut-down", a short period of rest is often of great advantage in regaining the lost function; additional x-rays should always be taken to ascertain the possible presence of new bone formation which, if disclosed, is a contra-indication to continued physiotherapy.

CASE REPORTS

Case 1. Shang Teh Sheng, a Chinese soldier, aged forty, fell from his horse three weeks before admission to the hospital, sustaining a severe injury to his right elbow, which he had held in a position of extension and supination when he attempted to break the force of his fall. Following the accident he noted that this elbow was stiff and very



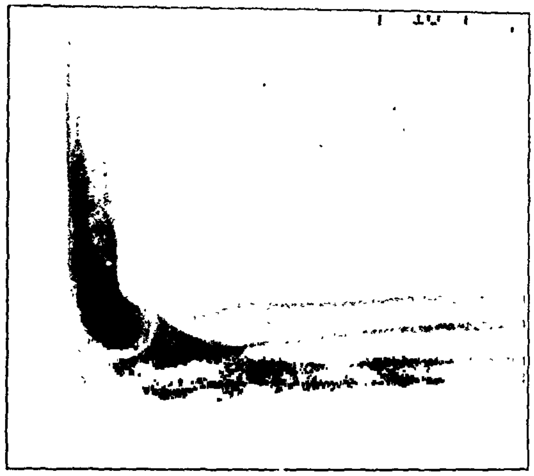


FIG. 11 FIG. 12

Case 1. Posterior dislocation of right elbow of three weeks' duration. *Fig. 11.* X-ray before operation. *Fig. 12.* X-ray after operation.

painful and at the same time swelling of the entire arm appeared, which subsided after a period of ten days.

Ten days prior to admission to the hospital he had had his elbow joint manipulated repeatedly by some Army surgeons in an effort to flex the forearm, but all attempts were unsuccessful and he was still unable to use the right arm. Family history and past history were irrelevant.

Physical Examination: Outside of the local surgical condition, there was nothing unusual in the general physical examination. The patient's right arm was held in a position of 175 degrees at the elbow joint with a limited range of flexion and extension of ten degrees. Pronation and supination were also markedly limited. In the cubital fossa was a mass which on palpation was considered to be the lower end of the humerus. The olecranon process of the ulna was higher than normal. There was about one-half inch of shortening of the right arm. Examination for possible nerve injury revealed anaesthesia of the ulnar side of the right hand with inability to abduct and adduct the fingers, and definite weakness of the ring and little fingers.

Diagnosis: A clinical diagnosis of "posterior dislocation of the right elbow with ulnar nerve injury" was made. X-ray report stated "complete backward dislocation of the

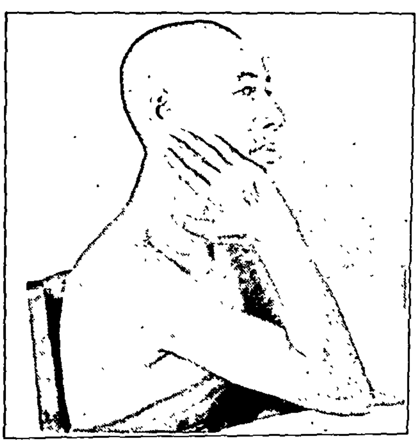


FIG. 13-A

Case 1. Condition one year after operation, showing voluntary flexion.

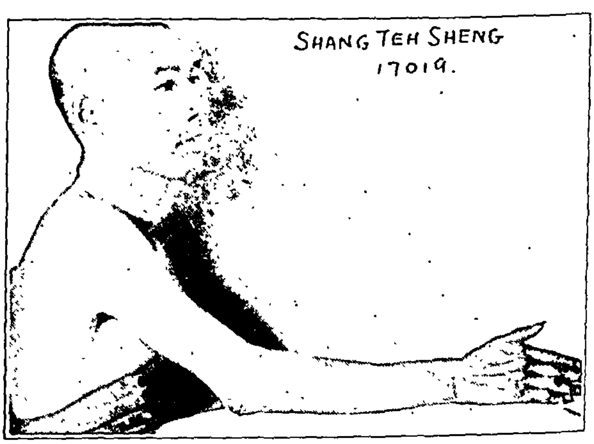


FIG. 13-B

Case 1. Condition one year after operation, showing voluntary extension.

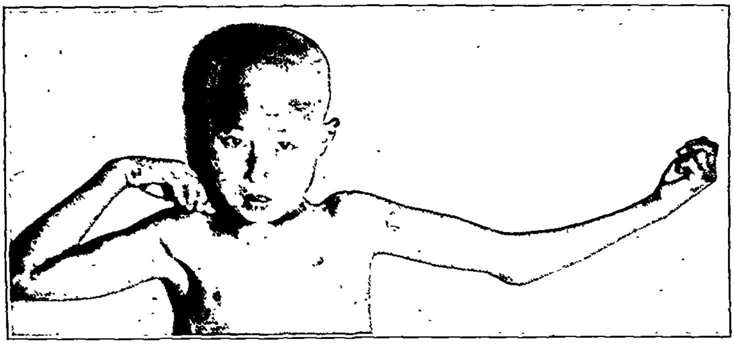


FIG. 14

Case 2. Posterior dislocation of left elbow of eighty days' duration, showing condition before operation.

elbow joint without gross fracture, but with slight new bone production, presumably a result of periosteal stripping from the lateral epicondyle".

Preoperative Notes: An attempt at closed reduction of the dislocation was made under ether anaesthesia, care being taken not to fracture the olecranon tip. The result was a failure. Following manipulation, the arm was protected and placed at rest to allow for the subsidence of swelling. Two weeks later operation was performed.

Operation: Open reduction of old irreducible dislocation of the right elbow. Autogenous tendon graft from tendo achillis to triceps tendon.

Postoperative Course: First dressing on the tenth day, stitches removed. Wound healed *per primum*. Cast discarded. Arm held in acute flexion by Jones sling. Gentle motion started. Postoperative x-ray report states that the bones of the joint are now in normal position.

Discharge Note: Patient left the hospital one month after operation and continued physiotherapy for another month, when he was forced to return to his regiment. At this time, examination showed flexion to be perfect, rotation perfect, and extension 165 degrees. The ulnar nerve weakness showed evidence of improvement.

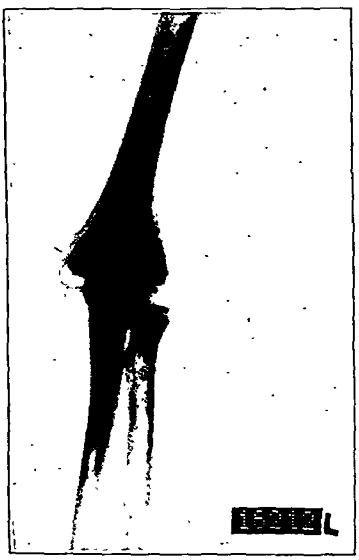


FIG. 15-A

Case 2. Anteroposterior view before operation.

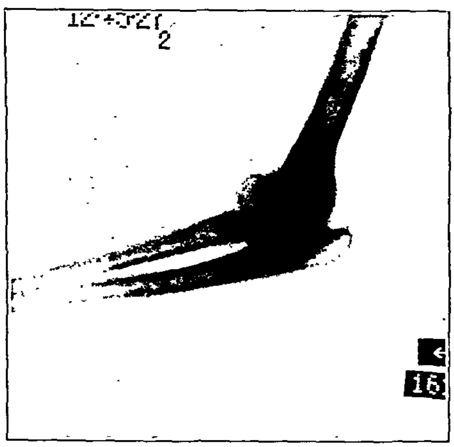


FIG. 15-B

Case 2. Lateral view before operation.

Follow-up: One year after operation the patient was again examined. His right elbow showed almost perfect function with the exception of ten degrees' limitation of extension. The transplanted tendon was functioning very well and voluntary extension, although not quite so strong as on the normal side, was satisfactory and increasing in degree.

CASE 2. Ma Shih Tsao, a Chinese farmer boy, aged fourteen, fell from a donkey's back eighty days before admission and injured his left elbow. Immediately following the accident there was extreme pain and swelling in the joint and he was unable to flex it. A local doctor was consulted who massaged the joint and applied a wooden splint with the arm in its extended position. One month later this splint was removed, but the patient was still unable to bend his arm. Family history and past history irrelevant.

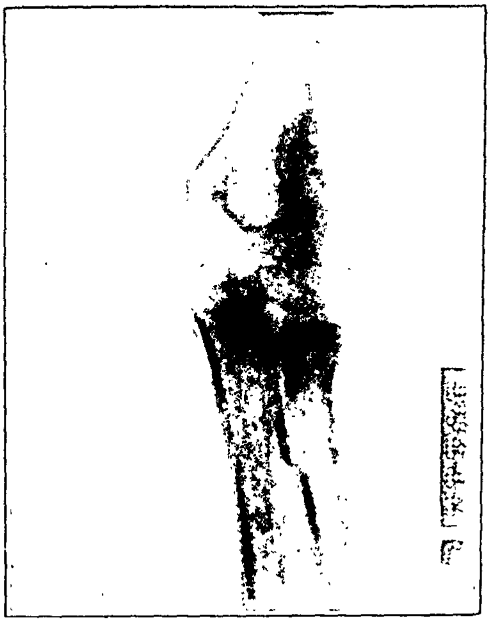


FIG. 16-A

Case 2. Anteroposterior view after operation.

FIG. 16-B

Case 2. Lateral view after operation.

Physical Examination: There was nothing remarkable in the general physical examination. Locally the left arm was held in an extended position of 150 degrees, and could not be moved more than a few degrees at the elbow. The elbow joint itself appeared abnormal in contour and palpation revealed the olecranon displaced posteriorly. Pro-

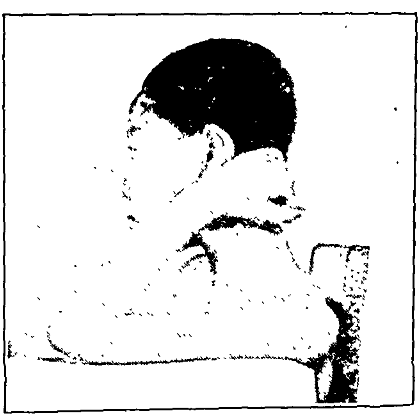


FIG. 17-A

Case 2. Condition four months after operation, showing voluntary flexion.

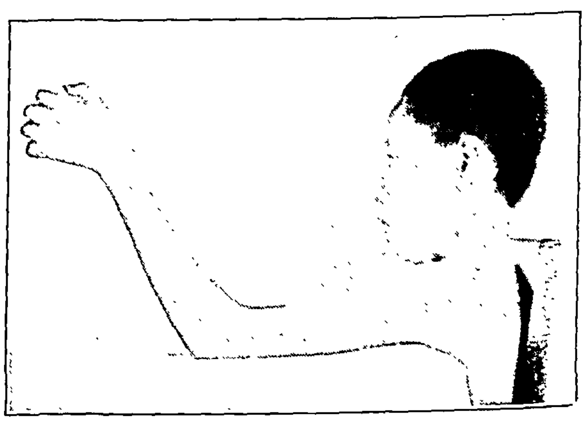
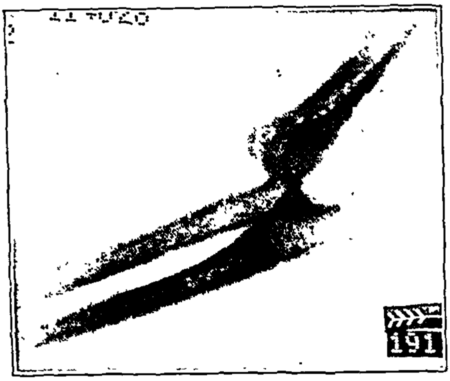


FIG. 17-B

Case 2. Condition four months after operation, showing voluntary extension.



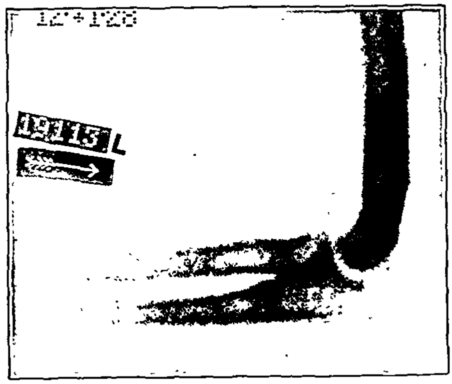


FIG. 18 FIG. 19

Case 3. Posterior dislocation of left elbow of four weeks' duration. Fig. 18. X-ray before operation. Fig. 19. X-ray after operation.

nation and supination were limited. All of the characteristic signs of an old posterior dislocation of the elbow joint were in evidence. No peripheral nerve injury was detected.

Diagnosis: A clinical diagnosis of "old irreducible posterior dislocation of the left elbow joint, with question of associated fracture", was made. X-ray examination showed "fracture dislocation of the left elbow with considerable new bone attached to the posterior surface of the distal end of the humerus".

Operation: Open reduction of old posterior dislocation of left elbow joint, complicated by supracondylar fracture. Autogenous fascia transplant from fascia lata to triceps tendon.

Postoperative Notes: Convalescence uneventful, except for partial anaesthesia over ulnar distribution of the left hand and ulnar weakness. All stitches out on the fourteenth day postoperative. Wounds healed *per primum*, and physiotherapy was begun. Postoperative x-ray examination showed the bones of the joint to be in normal position.

Follow-up: Four months after operation the voluntary movements of the left elbow were as shown in the accompanying photographs and the ulnar nerve condition was steadily improving. Two years after operation the patient's father reported that there was no pain in the elbow, rotation was unrestricted, the ulnar nerve involvement had cleared up entirely, and flexion of the joint was unlimited but extension was restricted to 160 degrees by actual measurement.

CASE 3. Wang Hai Ning, a Chinese merchant, aged nineteen, fell from his horse twenty-seven days before admission, with his left arm in an extended position. He lost consciousness for a few minutes and upon awakening felt great pain in his left elbow which appeared to be locked in an extended position. A Chinese doctor applied some splints to his arm without altering its position and painted some medicine on the skin to relieve the intense swelling. Because of no apparent relief under this treatment, he came to the hospital to be cured. Family history and past history irrelevant.

Physical Examination: The general physical examination showed nothing remarkable. Locally the left arm, which appeared to be swollen, was held in an extended position and could not be flexed or rotated beyond a few degrees at the elbow. All movements caused pain. Examination of the elbow joint proper showed a disturbance of the normal bony landmarks, the olecranon tip resting two and five-tenths centimeters above the level of the condyles, and the distal end of the humerus projecting forward into the cubital fossa. There were no signs of peripheral nerve injury and no definite evidence of fracture.

Diagnosis: The clinical diagnosis was "old posterior dislocation of the left elbow joint". X-ray diagnosis was "complete posterior dislocation of the left radius and ulna with no evidence of gross fracture".

FIG. 20-A

Case 3. Condition six months after operation, showing voluntary flexion.

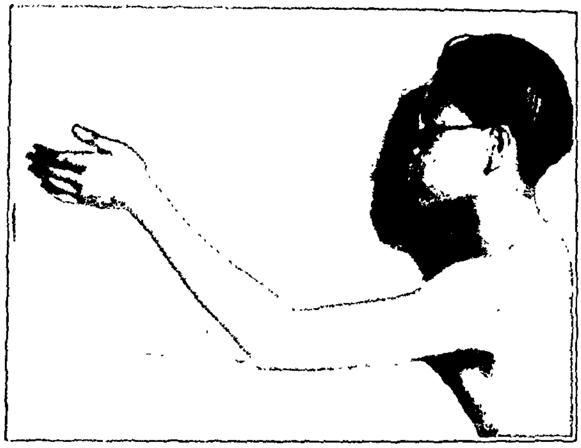


FIG. 20-B

Case 3. Condition six months after operation, showing voluntary extension.

Operation: Open reduction of old posterior dislocation of the left elbow joint. Autogenous tendon graft from tendo achillis to triceps tendon.

Postoperative Notes: Convalescence uneventful. Stitches removed on the tenth day. Both leg and arm wounds healed *per primum*. Plaster cast discarded and forearm held acutely flexed by Jones collar-and-cuff suspension. Gentle motions of the elbow started. Postoperative x-rays showed perfect reduction of the dislocation.

Follow-up: Six months after operation, the degrees of voluntary motion in the left elbow ranged between fifty and 130 as shown in the accompanying illustrations.

CASE 4. Wu Ching Po, a Chinese laundry woman of thirty-five, fell on her right elbow three months previously, while walking with a pail of washed clothing in her arms. As a result of the accident she noted that her elbow was locked in an extended position and was extremely sensitive to the least motion. Pain and swelling gradually subsided, however, while she kept her arm supported by a sling for a period of two months. Upon removal of the sling, the forearm gradually straightened a little more, but she was not able to flex it. Family history and past history were irrelevant.

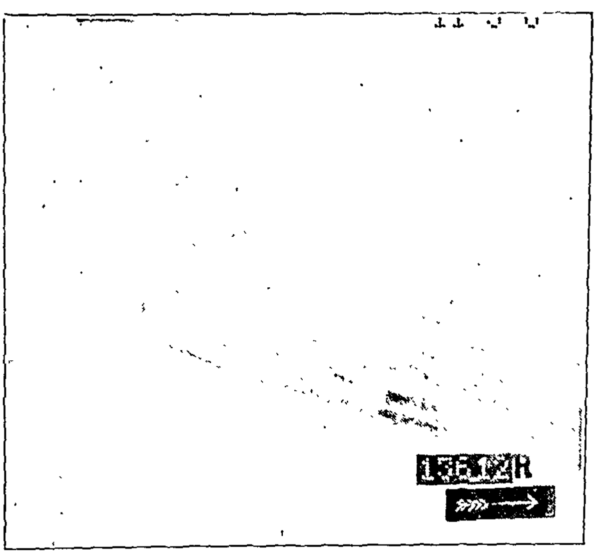


FIG. 21-A

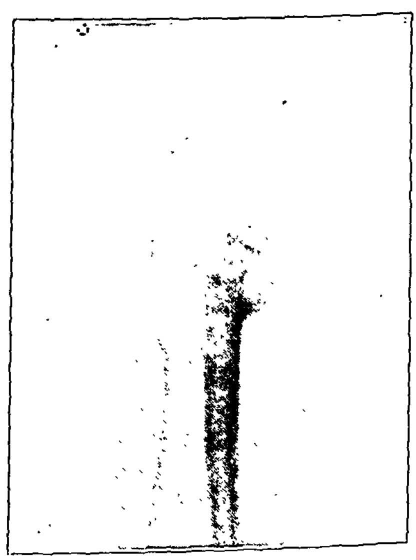


FIG. 21-B

Case 4. Posterior dislocation of right elbow of three months' duration. X-rays taken on admission to hospital.

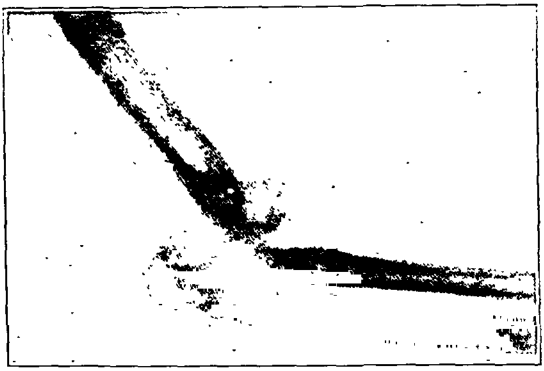


FIG. 22

Case 4. X-ray showing condition after attempt at closed reduction of dislocated elbow. The olecranon has been fractured.

FIG. 23

Case 4. X-ray showing condition after operation.

Physical Examination: Aside from the local surgical condition there was nothing unusual in the patient's general physical examination. Her injured arm was held in an extended position at the elbow, and could be flexed only a few degrees. Lateral mobility was increased, however. Palpation of the structures forming the joint showed the olecranon displaced upward and the distal end of the humerus resting anteriorly in the cubital fossa. There was no definite evidence of fracture, and no signs of peripheral nerve injury.

Diagnosis: The clinical diagnosis was "old posterior dislocation of the right elbow, associated with recent fracture of the olecranon". X-ray diagnosis corroborated the clinical diagnosis.

Preoperative Note: Under ether anaesthesia, an attempt was made to reduce the dislocation by the closed method. It not only failed but resulted in a fracture of the olecranon, making an operative procedure imperative.

Operation: Open reduction of old dislocation of the right elbow, wiring of olecranon. Autogenous tendon graft from the tendo achillis to triceps tendon.

Postoperative Course: Convalescence was uneventful. Stitches were removed on the fourteenth day. Both arm and leg wounds healed

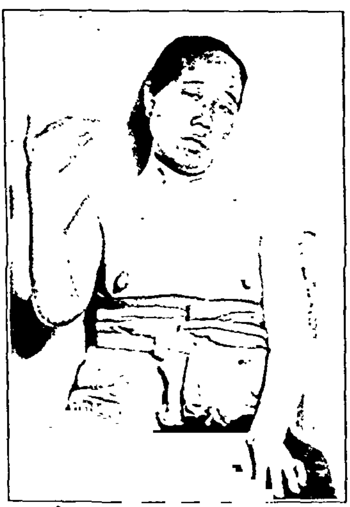


FIG. 24-A

Case 4. Condition three months after operation, showing voluntary flexion.

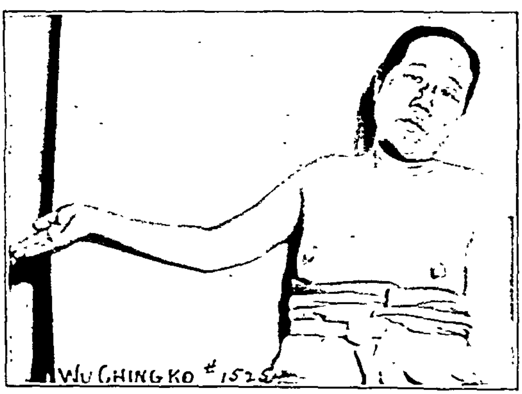


FIG. 24-B

Case 4. Condition three months after operation, showing voluntary extension.

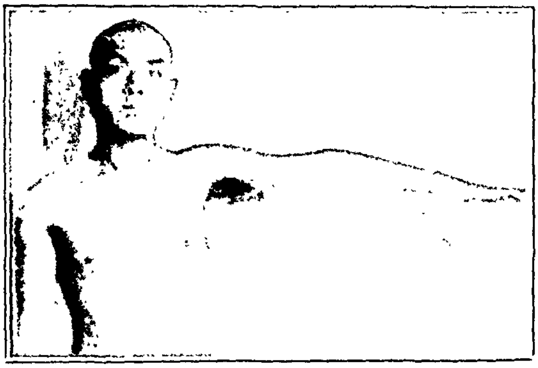


Fig. 25

Case 5. Posterior dislocation of left elbow of three months' duration, with arm locked in position of extension.

nicely. Cast was discarded and gentle motions of the elbow joint were started two weeks after operation. Forearm was held in acute flexion by Jones collar-and-cuff suspension. Postoperative x-ray examination showed a perfect reduction of the dislocation and the fractured tip of the olecranon held in place by wire. At the time of leaving the hospital she could flex the elbow to fifty degrees and extend it to 135 degrees.

Follow-up: Three months after operation the range of voluntary elbow motion as shown in the accompanying photographs was seventy-five degrees. Passive motion showed flexion to be thirty degrees and extension 160 degrees. Pronation and supination were unrestricted.

Case 5. Wang Tzu Liang, a Chinese merchant of twenty-one years, fell from his bicycle about three months previously and dislocated his left elbow, the left arm being locked in a position of extension. Soon after the injury he was treated by a Chinese native doctor who manipulated his arm, but failed to obtain a reduction of the dislocation. During the past three months, the pain and swelling had gradually disappeared but the patient was not able to flex his arm.

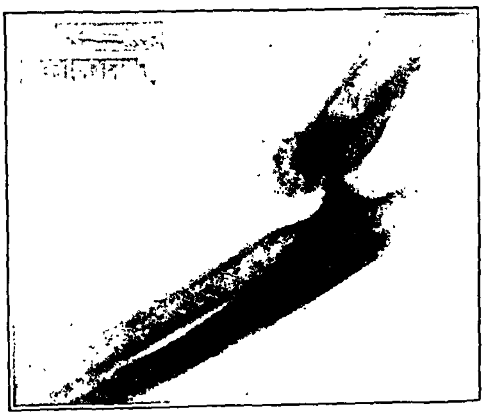


Fig. 26

Case 5. X-ray before operation.

Fig. 27

Case 5. X-ray after operation.

Fig. 28-A

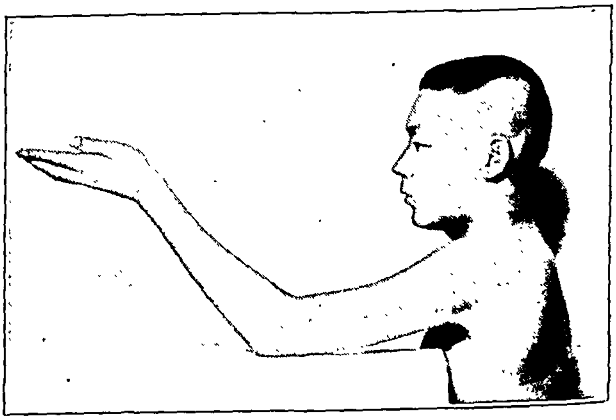


Fig. 28-B

Case 5. Condition two months after operation.

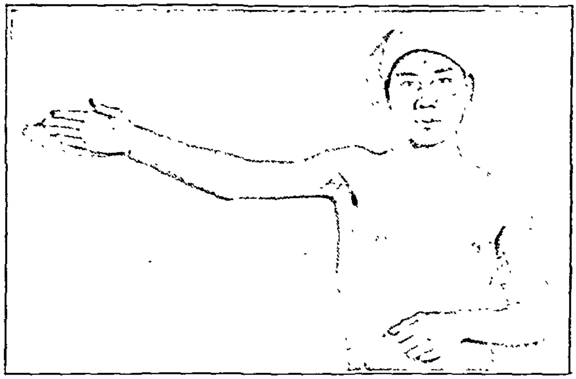


Fig. 29

Case 6. Posterior dislocation of elbow of two months' duration, showing fixed extension deformity.

Physical Examination: There was nothing unusual in the patient's general physical examination aside from the condition of his left elbow joint, which was held in an extended position and permitted only a few degrees of motion. The normal relationship of the bones at the elbow was disturbed, the olecranon being felt above the interepicondylar line, and the cubital space contained a bulging mass that was considered to be the lower end of the humerus. Actual measurements showed the left arm to be two centimeters shorter than the right. There was no evidence of peripheral nerve injury.

Diagnosis: The clinical diagnosis was "old posterior dislocation of the left elbow joint". X-ray diagnosis: "Complete dislocation of the radius and ulna posteriorly, the coronoid process impinging on the posterior surface of the medial epicondyle of the humerus. There is a fairly large amount of new bone formation on the lower anterior and posterior surfaces of the humerus."

Operation: Open reduction of old posterior dislocation of the left elbow joint. Autogenous tendon graft from tendo achillis to triceps tendon.

Postoperative Notes: Convalescence was uneventful. Wound healed by primary union. Sutures and arm cast were removed on the fourteenth day. Forearm was held in acute position by means of a Jones collar-and-cuff sling. Gentle exercises were started. Postoperative x-ray examination showed "good position of the bones of the left elbow joint after reduction of the dislocation".

Discharge Note: The patient was transferred to the convalescent home three weeks after operation, at which time the range of motion in his left elbow joint was between forty-five and ninety degrees.

Follow-up: Two months after operation, examination showed active movements of the elbow to be fifty-four degrees' flexion and 132 degrees' extension. Passive movements were forty-nine degrees' flexion and 136 degrees extension. Another x-ray taken at this time to ascertain the cause

Fig. 30-A

Case 6. Anteroposterior view before operation.

Fig. 30-B

Case 6. Lateral view before operation.

of limitation of motion showed the formation of new bone anteriorly, which interfered with flexion. No apparent cause was found for the limited extension, however.

Case 6. Hu Ho Pao, a Chinese male of twenty years, fell out of a rickshaw two months previously and injured his right elbow. Since then, there had been pain and swelling, also deformity of the joint and he had not been able to flex his forearm, which remained locked after the accident in a position of extension. He had had massage and manipulation of the joint by native practitioners without improvement. Family and past history irrelevant.

Physical Examination: The right forearm was held at an angle of 160 degrees' extension, only a few degrees of flexion and extension being possible from this position. Lateral mobility was increased beyond normal. Rotation was slightly limited. The olecranon was prominent posteriorly and could be palpated above the intercondylar line. There was an ab-

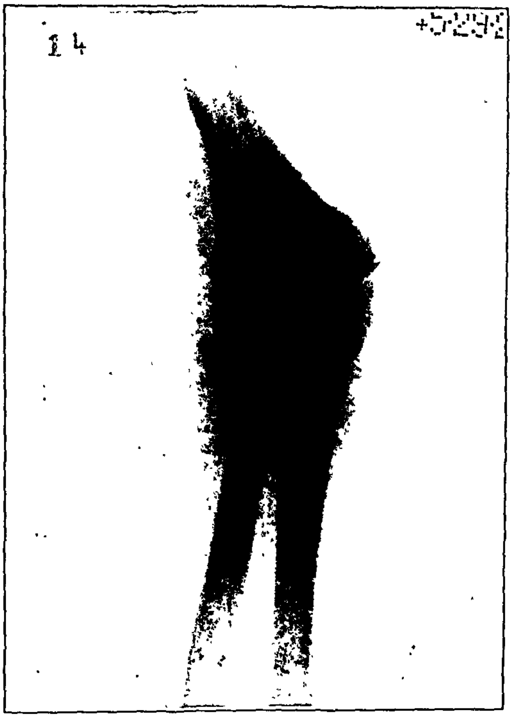


Fig. 31-A

Case 6. Anteroposterior view after operation.

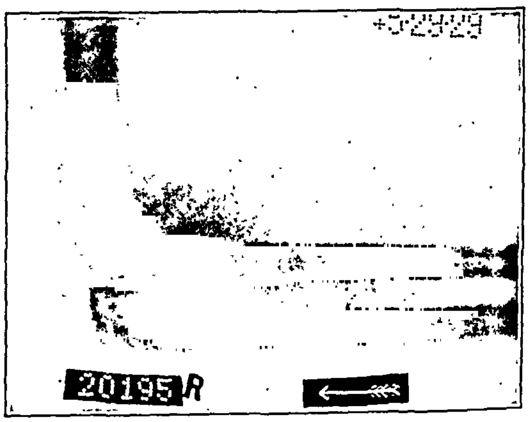


Fig. 31-B

Case 6. Lateral view after operation.

Fig. 32-A

Case 6. Condition two months after operation, showing voluntary flexion.

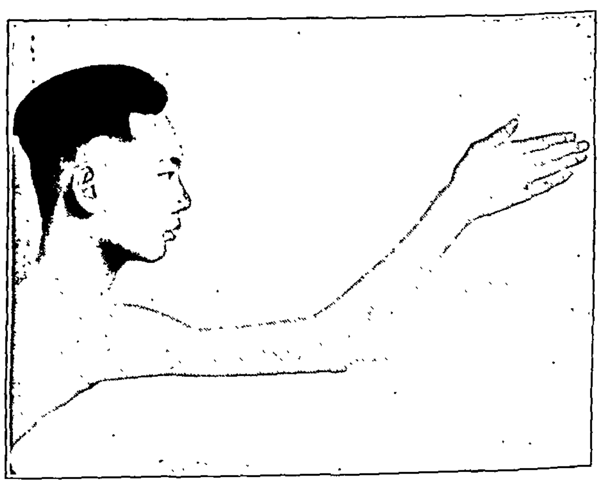


Fig. 32-B

Case 6. Condition two months after operation, showing voluntary extension.

normal fullness of the antecubital space and an apparent shortening of the forearm as compared with the opposite side. There was no evidence of nerve injury.

Diagnosis: A clinical diagnosis of "posterior dislocation of the right elbow joint" was made, and the x-ray report confirmed this, adding that there was evidence of injury to the periosteum of the medial epicondyle of the humerus.

Operation: Open reduction of old posterior dislocation of the right elbow. Autogenous fascia transplant from fascia lata to triceps tendon. Plaster shell from the shoulder to fingers with elbow in right-angle position.

Postoperative Notes: Uneventful convalescence. Operative wounds healed *per primum.* Cast was discarded at the end of two weeks and exercises started. Jones collar and cuff employed. Postoperative x-rays showed the relationship of the bones of the elbow to be excellent with their articular surfaces in normal position.

Discharge Note: Patient was transferred to the convalescent home three weeks after operation, at which time, his right elbow motions showed fifty degrees' flexion and 130 degrees' extension.

Follow-up: The patient was last seen by the writer three months after his operation, when examination showed flexion of the right elbow joint to be normal and extension to equal 175 degrees.

DISCUSSION

In the actual reduction of old posterior dislocations of the elbow, it is perfectly evident that two main obstacles have to be overcome: (1) the contracted triceps tendon, and (2) the mass of fibrous tissue and callus that collects in the triangular space bordered by the posterior surface of the lower end of the humerus, the triceps tendon, and the dislocated olecranon incisura (Fig. 8). The contracted triceps tendon must be either stretched, separated from its insertion, or lengthened, and the mass of tissue, resulting from blood clot, torn capsule, and separated periosteum, must be completely removed from behind the humerus before a perfect reduction can be secured.

Forceful stretching of the triceps in cases of long standing is so productive of trauma both to muscles and to the trochlea of the humerus as to be unjustifiable. Separation of the triceps insertion by subperiosteal dissection or by osteotomizing the olecranon (the transolecranon approach) has long been the method of choice for many European and American surgeons, but it has the distinct drawback of not permitting easy approximation of the divided structures for suture after reduction is accomplished. In fact, approximation of the tendon to its insertion is so frequently impossible after reduction, that the lower end of the humerus is often sacrificed in order to accomplish the purpose. Even should it be possible—as in the rare case—to suture the olecranon back into position or the tendon back to the periosteum, the forearm invariably must be kept in a position of extension in order to relieve tension on the sutures; this position prevents early function, favors recurrence of the dislocation, and is decidedly detrimental to a favorable result.

The lengthening of the triceps tendon is a more recent method of overcoming the muscle contraction, and has been accomplished in several ways, one of which has been a simple "step-cut" lengthening procedure;

and another a dissection of the tendon from its muscle attachments and sliding it distally to a new position between the divided muscle edges after the method of Bennett[1]. A somewhat similar procedure has been advocated by Speed[2].

The objection to the "step-cut" operation is largely anatomical, in that the tendinous portion of the triceps muscle is not over one and one-half inches in length, which does not allow sufficient lengthening of it with adequate suture to serve the best requirements of future function. For early cases, or those in which the triceps muscle length has been maintained, this method can undoubtedly be used with success; but as a safe and sure procedure for all cases, it is, in the writer's judgment, definitely inadequate.

The dissection of the tendon from its muscle attachments, and sliding it distally to an insertion at a lower level, also has disadvantages. Chief of these is the anatomical relationship of the triceps tendon to its muscle. The tendon divides into two separate layers as it extends upward into the muscle tissue, which means that to dissect it away from all of its attachments requires a cutting of considerable muscle tissue and an undue amount of trauma. Because of this anatomical relationship, the writer feels that the *triceps muscle and tendon are not suitable for this kind of procedure.* In his hands it always seemed a rather messy, bloody, and unavoidably traumatic operation, and the suture repair not very satisfactory. In addition, he and his colleagues have found difficulty in certain cases in securing sufficient lengthening of the triceps muscle even by this method.

The use of tendon or fascia lata as a means of lengthening the triceps has the advantage of permitting any required length without sacrificing unduly the strength and function of the muscle. This fact was appreciated after the published work of Gallie[3], who in 1922 showed that transplanted fascia and tendon would not only remain alive but would unite with other body structures.

Lengthening of the triceps tendon by this method has obviated, in the writer's experience with elbow dislocations unassociated with fracture, the necessity for partial or complete resection of the joint. Resection should be reserved only for dislocations with complicating joint fractures or those associated with infection. It no longer has a place in old uncomplicated dislocations of the elbow and its connections with this condition in the future should be only historical. With our newer surgical methods, we need no longer shorten the humerus at its articulation in order to obtain reduction but rather secure a far happier result by lengthening the triceps tendon.

SUMMARY

In posterior dislocation of the elbow of over three weeks' duration, closed methods of reduction are contra-indicated.

In old posterior dislocations of the elbow, uncomplicated by fracture, operative reduction is demanded; and the operative procedure of choice is the one which will allow careful preservation of the articulating joint surfaces and a reduction of the dislocation with a minimum of trauma.

A simple operative method which has been successful in accomplishing these two purposes is presented by the writer with a report of six cases.

Resection should have no place in the treatment of old uncomplicated posterior dislocations of the elbow, but be reserved for cases associated with major fractures or infection.

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EARLY SIGN OF TUBERCULOUS SPONDYLITIS IN THE PREGIBBUS STAGE*†

From the Department of Bone Diseases of the Odessa State Institute of Tuberculosis

BY DR. S. KOFMAN, ODESSA, U. S. S. R.

TRANSLATED FROM THE GERMAN BY EMANUEL KAPLAN, M. D., NEW YORK, N. Y.

The early diagnosis of spondylitis is of primary importance. The roentgenogram in the early stages is unreliable. The classical symptoms are: pain, loss of motion, and deformity. The first is not always reliable; the second requires experience and the ability of observation; the third is relatively a late symptom not present in twenty per cent. of the cases. Many years of observation have taught us that there should be some evidence of the disease in its initial pregibbus stage.

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†This clinical sign is also mentioned in a paper presented by Dr. Kofman at the meeting of the Orthopaedic Association in Leningrad, April 6, 1931, which paper is published in full in *Archiv für Orthopädische und Unfall-Chirurgie*, XXX, 308, 1931.

In examining a healthy individual, with his back facing the light and his arms hanging at the sides, there is seen an irregular groove extending along the spine from the neck to the sacrum. This groove varies in depth according to the muscular development of the individual, and is enclosed between the two muscular bands of unequal thickness along their course. If the spine is affected, it is observed that these muscular bands diverge more or less, forming a rhomboid or an oval-shaped depression—"*Delle*". Palpation of the muscles encircling the depression (sacrolumbalis) shows them to be soft, somewhat doughy, and that they do not contract. This is more evident with the patient in a prone position.

Our observation for the last five years has demonstrated this depression, *Delle*, to be the location of the future gibbus. Rarely, two or three depressions are present, which is an indication of double or triple localization. An atrophy of the entire back, an absence of the spinal groove, with soft muscles suggest the presence of an affection of the entire spine. Sometimes two or three years elapse before the gibbus deformity becomes evident, and, in rare instances, the gibbus does not appear at all (spondylitis superficialis anterior of Hoffa), but other manifestations—abscesses, lameness, etc.—occur, which indicate the presence of the probable lesion. We have observed cases in which the diagnosis of spondylitis was established two or three years in advance, although the roentgenogram (with the exception of a slight narrowing of the intervertebral disc) and the other manifestations did not indicate the presence of a lesion.

The appearance of the oval depression, *Delle*, with the flattening of a definite part of the spinal groove, is not in itself pathognomonic of a tuberculous lesion of the spine, but indicates that this part of the spinal column does not participate in the motion of the entire spine; it may be observed in spondylitis and other processes involving the mobility of the spine. The specific sign is the softening of the long muscles of the back. The muscular attachments which arise from the affected vertebrae lose their tonus in the same manner that the quadriceps femoris loses its tonus in tuberculous gonitis.

It is interesting to observe that, in case of a favorable turn in the process, the muscles regain their contractility and firmness.

FUSION OF THE ELBOW JOINT FOR TUBERCULOSIS

A New Technique and a Report of Three Cases

BY HALFORD HALLOCK, M.D., NEW YORK, N. Y.

Fellow of the New York Orthopaedic Dispensary and Hospital

A description of a new technique for fusion of the elbow joint and the reports of three cases treated by fusion are given. The first two cases were fused in the manner to be described. The third one had to be fused in a different way because of gross involvement of the olecranon bone by the disease, for the subsidence and repair of which we had unwisely waited. The principle of the procedure lies in the use of a mass of cancellous bone, the olecranon process, with its soft-tissue attachments intact, to bridge the joint from humerus to ulna. It is modeled from the method of hip fusion described by Dr. Russell A. Hibbs in *The Journal of Bone and Joint Surgery* (VIII, 522, July 1926). Microscopic sections from triceps tendons in cadavera studied in our laboratory have shown the presence of blood vessels running from the tendon and its surrounding connective tissue into the bone of the olecranon, and it is believed that such a mass of bone, with these vascular connections intact, provides a favorable situation for bone growth and fusion.

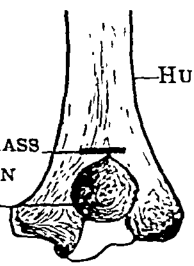

Fig. 1

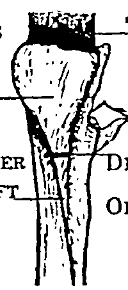

Fig. 2

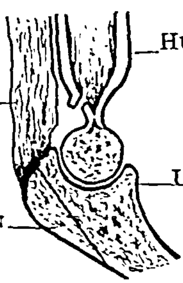

Fig. 3

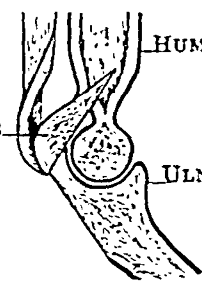

Fig. 4

OPERATIVE TECHNIQUE

With the patient in the prone position and the elbow flexed over a support on the arm board, a dorsal mid-line incision is made and the posterior region of the elbow joint exposed. The periosteum of the ulna is divided along both sides of the subcutaneous olecranon surface and down the posterior border of the shaft, and the sides of the olecranon process and upper ulnar shaft are exposed subperiosteally. This exposure is accomplished easily and pushes the ulnar nerve away from the immediate operative area. The posterior half of the olecranon with its periosteum and triceps tendon, together with some of the ulnar cortex, is raised with a chisel and reflected proximally. This exposes the joint, and tissue is removed for examination. The superior surface of the olecranon stump and the posterior aspect of the humerus are bared and a slot cut obliquely upwards into the humerus at the upper border of the olecranon fossa. The mass of bone with its muscle attachment is mobilized, rotated 180 degrees, and driven into the humerus so that the original distal end penetrates deeply into that bone and the proximal portion comes to lie against the bared stump of the olecranon with the elbow flexed at 120 to 130 degrees. (Full extension is considered as 180 degrees.) If desired, a few bone chips, easily obtained from adjacent healthy areas of humerus or ulna, may be placed along the line of contact with the ulna, and the mass is then anchored to the ulna with chromic periosteal sutures. The wound is closed in layers and a plaster cast applied from hand to axilla.

CASE REPORTS

Case 1. A.U. 5668. An Italian woman of fifty admitted to the wards of the New York Orthopaedic Dispensary and Hospital, December 19, 1928, complained of trouble with the left elbow since 1914. She had been followed in the dispensary from 1914 and

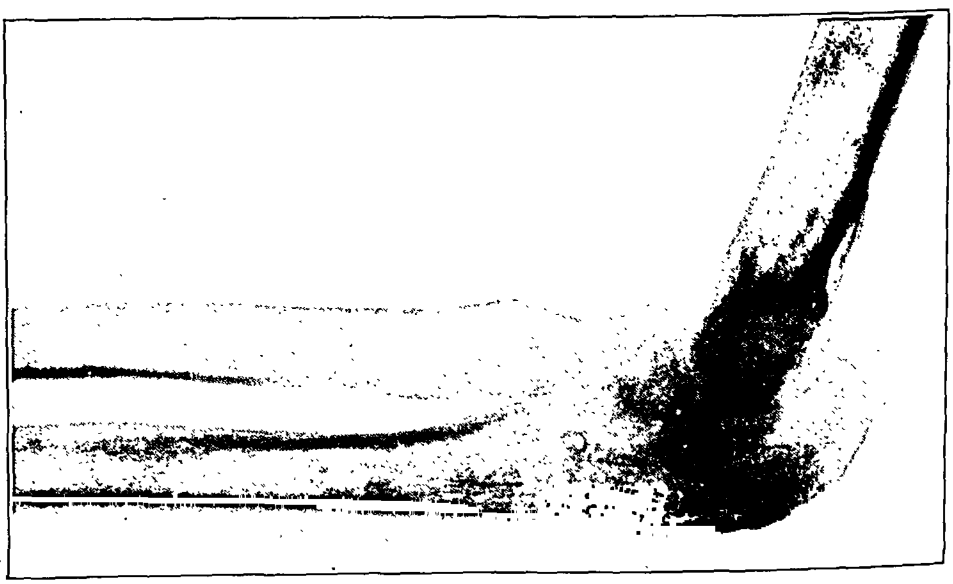

Fig. 5
Case 1, No. 5668. Preoperative x-ray.

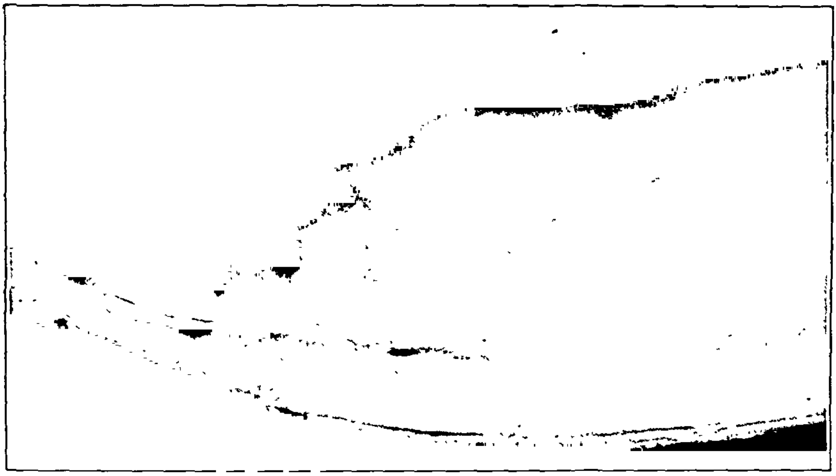

FIG. 6
Case 1, No. 5668. Postoperative x-ray.

had been treated with braces and the aspiration of an abscess early in the course of the disease. The clinical diagnosis was tuberculosis. Periods of remission occurred but the symptoms always returned.

Examination: The left elbow was swollen, thickened, and tender. It was held at ninety-five degrees' flexion and permitted only ten degrees of motion, which was accompanied by acute pain and spasm. Pronation and supination were limited to five degrees. An old sinus scar was present. The x-ray showed marked loss of substance with some reparative changes and suspicious evidence of effusion anteriorly.

Operation: Elbow fusion, left, December 27, 1928. Granulation tissue, appearing tuberculous in nature, was found within the joint. No pus was encountered. All bone used in the procedure was of good appearance and consistency. The elbow joint was fused in the manner previously described. A few bone chips were placed along the line of contact of mass and ulna.

Pathological report: Chronic inflammation with tubercle formation.

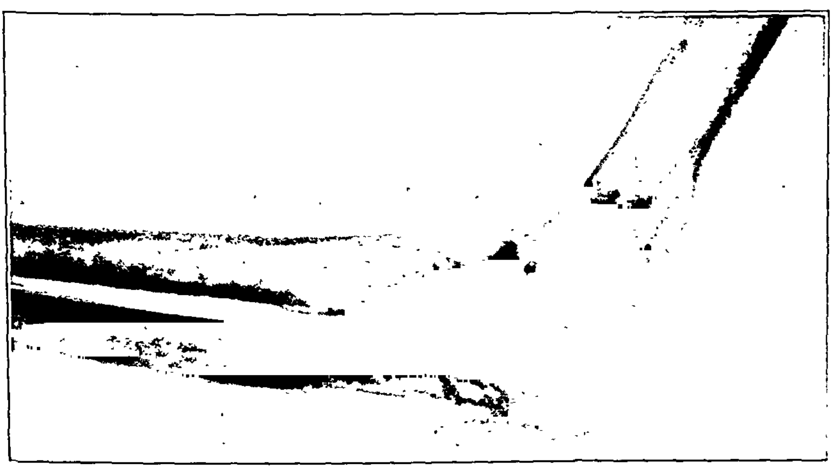

FIG. 7
Case 1, No. 5668. Six months after operation. Fusion through the transposed mass.

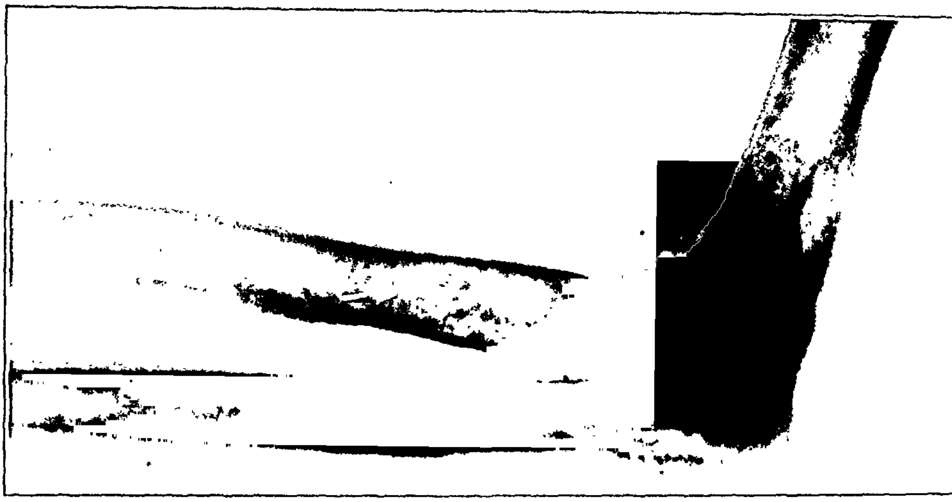

FIG. 8
Case 1, No. 5668. Two years after operation. Complete fusion of the joint.

Postoperative x-ray: Olecranon fragment in good contact with humerus and ulna and well implanted in the former.

Course: There were no operative complications and the wound healed well. On April 30, 1929, four months after operation, the plaster was changed. There was slight, springy motion but no pain or spasm. The x-ray indicated fusion. Plaster was retained until May 14, 1929, four and one-half months after operation. The elbow was clinically solid.

Follow-up examination: The patient has since been without pain or evidence of disease. The last examination, April 14, 1931, revealed a fused elbow at 120 to 130 degrees. There was no tenderness, swelling, spasm, or sinus. The forearm was held in a mid-position and allowed five degrees of pronation and forty-five degrees of supination without pain or spasm. The x-ray showed complete fusion of the joint.

CASE 2. R.D. 123204. An American male of twenty-two admitted to the hospital October 16, 1929, complained of pain and swelling in the left elbow of four years'

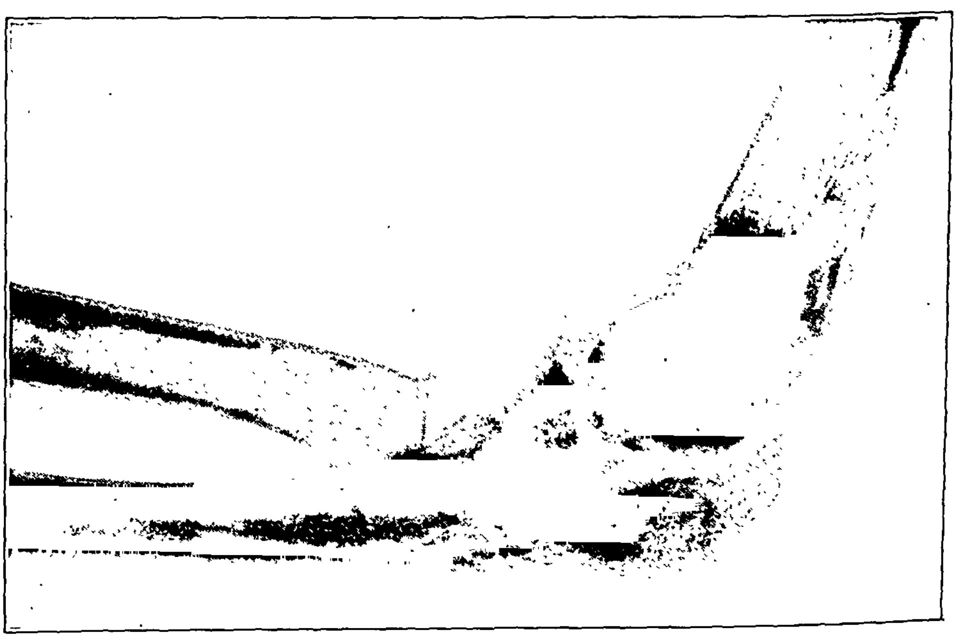

FIG. 9
Case 2, No. 123204. Preoperative x-ray.

FIG. 10
Case 2, No. 123204. Postoperative x-ray.

duration. In 1928 the joint was operated upon in another hospital and a resection of the radial head performed.

Examination: The left elbow was hot and swollen and was held at 100 to 110 degrees. Only ten to twenty degrees of motion was possible and was accompanied by acute pain and spasm. The x-ray showed loss of substance, erosion, smoky decalcification, and a dense, well defined effusion. There was slight productive reaction and the head of the radius had been resected.

Operation: Elbow fusion, left, October 21, 1929. Typical diseased granulation tissue was found in the region of the joint. The bone appeared to be of good consistency and

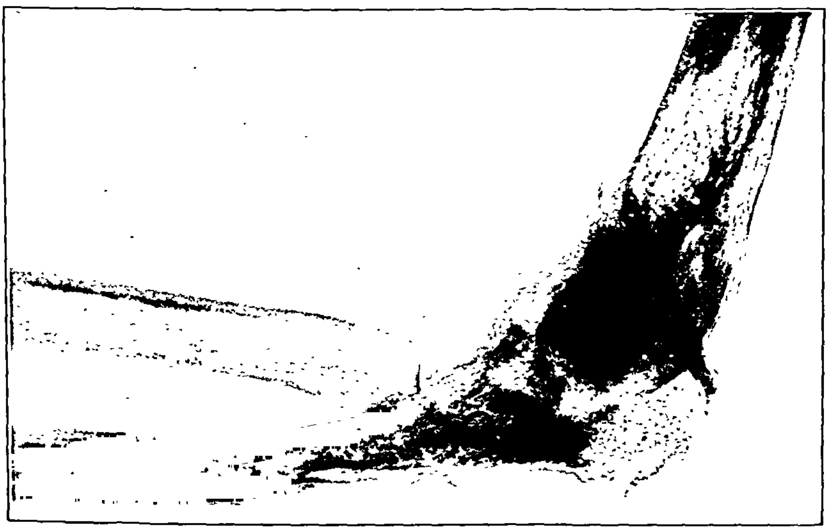

FIG. 11
Case 2, No. 123204. Prerefusion x-ray. Failure of fusion at site of greenstick fracture.

Fig 12

Case 2, No. 123204. Eleven months after refusion. Complete fusion of the joint.

no disease was encountered in it. Immediate frozen section revealed tuberculosis. The mass projected posteriorly and was green-sticked down over the bared posterior surface of the ulna and held with periosteal sutures. Bone chips were placed at the line of contact of mass and ulna.

Postoperative x-ray: Bones and fragments were well apposed at about 110 degrees. Distal end of mass green-sticked over posterior surface of ulna.

Course: There was a moderately severe postoperative reaction. The transposed mass united quickly and firmly at both ends, but bone absorption and a pseudarthrosis developed at the site of the green-stick fracture. On April 14, 1930, six months after operation, the man was admitted to the hospital for refusion.

Operation: Refusion of elbow, April 18, 1930. The transposed mass of bone was firmly united at both ends to humerus and ulna, but at the former site of incomplete fracture there was no union and the interval, as well as the posterior, part of the joint was filled with granulation tissue and some pus. The proximal portion of the transposed mass was removed, the posterior portion of the joint curetted and the area filled with bone chips removed from the left ilium. A new mass of bone, with the triceps attachment preserved, was raised from the olecranon, rotated 180 degrees, and driven obliquely into the posterior surface of the lateral condyle, the original proximal portion making good contact with the olecranon stump.

Pathological report: Tuberculosis.

Postoperative x-ray: Transplant and numerous small chips in excellent contact from ulna to humerus.

Course: There was again a moderately severe reaction. The wound healed well except for the development of two small sinuses. Four months after operation the elbow clinically and by x-ray was fused, but plaster was retained for two months more for safety while the patient was at a summer camp. Six months after operation the elbow was solid and the sinuses healed.

Follow-up examination: At the last examination, May 5, 1931, one year after operation, the elbow was fused at 130 degrees. There was no swelling, spasm, or sinus. The x-ray showed complete fusion of the joint. It is to be noted that in the elbow, as well as in the hip, fusion of the diseased bone ends follows upon the fusion of more healthy areas obtained by operation.

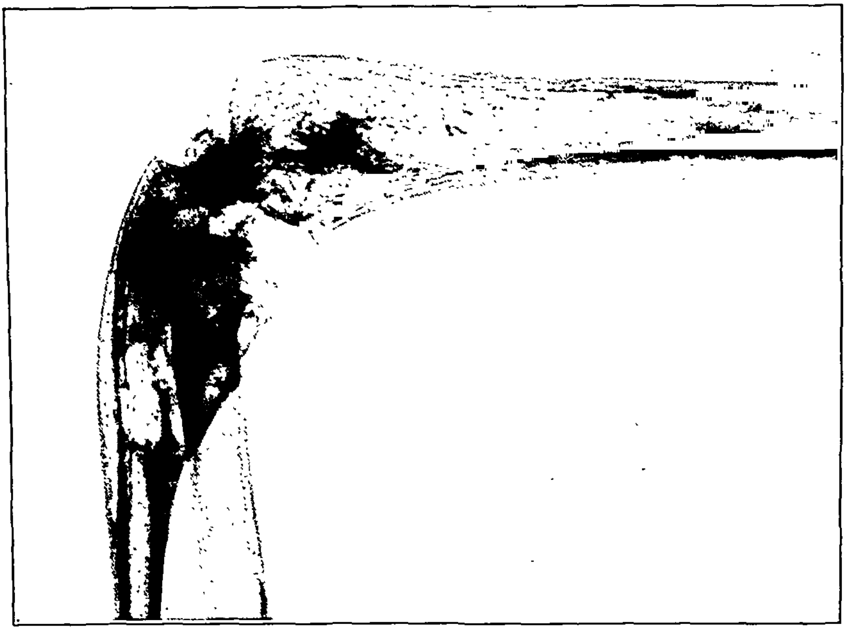

FIG. 13
Case 3, No. 106421. Preoperative x-ray.

The weakness in the technique in this case was the green-stick fracturing of the mass over the olecranon stump. The mass should have been either shorter in length or driven more deeply into the humeral shaft so that no projection would have occurred.

CASE 3. R.F. 106421. A two-year old Italian girl was admitted to the dispensary December 28, 1927. It was reported that for fifteen months she had been unable to straighten out the right elbow. The child appeared chronically ill. The elbow was held flexed, and swelling and spasm were present. The x-ray disclosed cavitation of the right ulna at the elbow, with effusion into the joint. The child was admitted to the hospital in March 1928 and the elbow was explored and found by microscopic section to be tuberculous. She was then sent to the country branch in the hope that under prolonged and controlled care the disease would subside and the bone repair, making the situation more

FIG. 14
Case 3, No. 106421. Five and one-half months after operation; one and one-half months before refusion. Pseudarthrosis opposite the joint line.

FIG. 15
Case 3, No. 106421. Postrefusion x-ray.

favorable for fusion. The disease seemed to subside but again became active, with abscess formation. Aspiration and then incision and drainage were done on September 19 and 25. After this the condition of the joint improved, but the disease never became inactive, and in April 1930 it was decided to proceed with fusion.

Operation: Elbow fusion, right, April 29, 1930. Gross disease was found in the elbow joint with such extensive involvement of the olecranon that it could not be used in the usual manner as a transposed mass with muscle attachment. Diseased granulation tissue was present in large amount and some pus was also found. As it was impossible to use the olecranon in the fusion procedure, the humerus and ulna were subperiosteally bared. The larger part of the diseased tissue and bone was removed and a shallow groove fashioned across the joint line, which was filled, from normal bone proximally to normal bone distally, with chips removed from healthy areas of humerus and ulna.

Pathological report: Tuberculosis.

Postoperative x-ray: Numerous small chips about ulna and humerus.

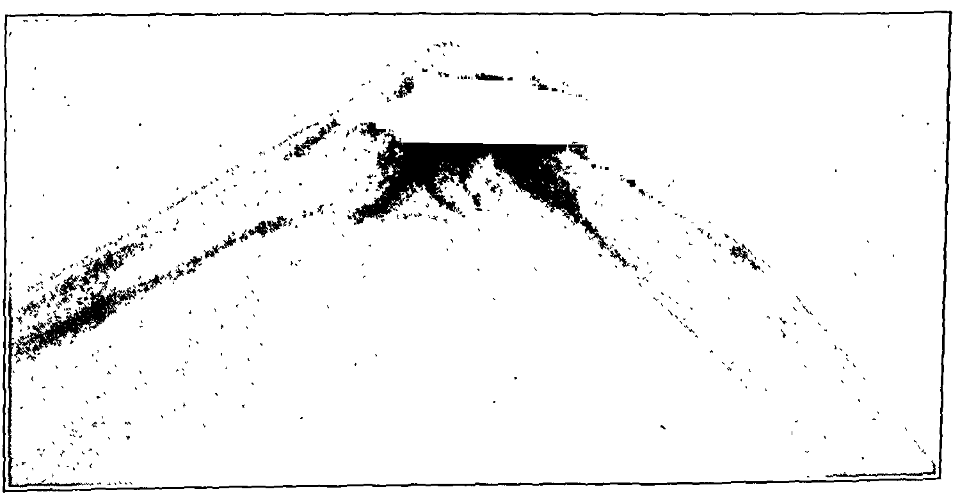

FIG. 16
Case 3, No. 106421. Six and one-half months after refusion. Complete fusion of the joint.

Course: The patient made an uneventful recovery but the elbow did not fuse. In November 1930, seven months after operation, it was decided to refuse the joint.

Operation: Refusion of right elbow joint, November 28, 1930. Two or three degrees of motion were present at the elbow joint through a line of pseudarthrosis. For the most part the intervening tissue was fibrous and the bone in fair condition, but deep in the joint granulation tissue and caseous material were found. The radio-ulnar joint, which was unintentionally opened, appeared normal and was closed at once. The area of pseudarthrosis was curetted and the bone cut back so as to make the line of non-union shallower. The whole area, from well up on the humerus to well down on the ulna and extending deep down into the joint, was packed with bone chips previously removed from the right ilium.

Pathological report: Tuberculosis.

Postoperative x-ray: Humerus and ulna in good apposition through the medium of abundant small chips.

Course: An uneventful recovery ensued and the elbow fused rapidly and well. On February 18, 1931, twelve weeks after operation, the joint was solid to gentle manipulation and there was no pain or spasm. The x-ray indicated fusion. Plaster was retained, however, until April 1, 1931, four months after operation, because of the strenuous activity of the child.

Follow-up examination: The last examination was made July 1, 1931, seven months after operation. The elbow felt solidly fused and was without pain, tenderness, or spasm. There were no sinuses and there had been no change in position. The forearm allowed forty-five degrees each of pronation and supination. The x-ray showed fusion and subsidence of disease.

The mistake in this case was to wait for disease subsidence and bone regeneration under prolonged conservative treatment. Valuable time was lost and increased hospitalization incurred.

SUMMARY

1. A new technique for fusion of the elbow joint is described. It consists of the use of a mass of cancellous bone, the olecranon, with its soft-tissue attachments intact, to bridge the joint from humerus to ulna, and is modeled from the method of hip fusion described by Dr. Russell A. Hibbs.
2. The reports are given of three cases of tuberculosis of the elbow joint treated by fusion.

SURGICAL TREATMENT OF LOW BACK DISABILITIES*

BY EDWIN W. RYERSON, M.D., CHICAGO, ILLINOIS

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When it has definitely been established that conservative treatment by mechanical, medicinal, and postural therapy has failed to relieve low-back disability, it becomes important to consider the possibility of relief by operation. In some patients, the pain and disability are not severe enough to warrant surgical interference. In some others, there exist contra-indications to anaesthesia or to the shock of operation. There remains, however, a large number of these sufferers who are materially handicapped by low-back disability and who are excellent surgical risks.

If this disability is known to be due to anatomical abnormality, such as spondylolisthesis or vertebral anomaly, or to weakness and instability of the joints, or is caused by an arthritis limited to the lumbosacral or sacro-iliac articulations, it is perfectly justifiable to attempt relief by arthrodesing or fusion operations designed to produce bony ankylosis of the affected joints.

In a fairly large series of such operations performed in the writer's clinic, the percentage of complete success has been so high that the procedure is confidently recommended as an almost certain means of relief.

The surgical risk is as small as in any other ordinary operation and the period of convalescence is scarcely more than the time involved in recovery from one of the acute attacks to which these people are subject.

We should, therefore, be ready to advise operation when the clinical picture is sufficiently clear, and should endeavor to convince the general practitioner that there is little danger and great possibility of cure in the surgical treatment of these conditions.

In many instances it is practicable to determine accurately the individual joint which is the seat of the disturbance. In most cases this is the lumbosacral joint. In a few it is the third or fourth lumbar joint. In a fair number it is one or both of the sacro-iliac joints. In some cases it has been impossible for the writer to be absolutely certain of the exact location of the disability, in spite of the most careful application of the usual special differential tests.

OPERATIVE TECHNIQUE

Because the operative fusion of the lumbosacral joint is most frequently utilized and is numerically the most important, it will here be considered first. The Hibbs technique undoubtedly produces excellent results where

*Read at the Annual Meeting of the American Orthopaedic Association, Memphis, Tennessee, April 16, 1931.

properly performed. It requires, however, more time and precision than is at all desirable. In certain cases where the bone-forming ability of the patient is at a low level, this operation may fail to produce a bony fusion. In most cases it is wise to add some large bone grafts taken preferably from the posterior crest of the ilium or from the tibia.

The Albee operation has the merit of greater rapidity. The writer, in 1911, performed the first lumbosacral fusion for spondylolisthesis that has been recorded, using an S-shaped, broad splint taken from the flat surface of the tibia. This operation was completely successful, and the patient twenty years later is perfectly well and has had no trouble with the back since the operation.

It is true, however, that in rare instances the Albee tibial splint has become absorbed in the course of months or years, through no fault in the technique, and after having united perfectly with the spinous processes of the vertebrae. This undesirable phenomenon has been observed in the practice of other surgeons, besides the four cases of the writer, and it creates a slight feeling of uncertainty in evaluating the procedure.

It would seem wise, therefore, to combine the merits of these two valuable and well standardized fusion operations and to perform a reasonably accurate Hibbs subperiosteal denudation of the laminae and spinous processes, with one or more large bone grafts removed from the iliac crest; these grafts being laid on the small Hibbs grafts or implanted in the split spinous processes.

This combined method has been used in a considerable number of cases operated upon in the writer's clinic, and with practically uniform success, and is recommended, without qualification, as being the safest and best technique, except where circumstances require the most extreme rapidity of operation. In the latter class of cases, the original Albee technique should be followed.

Sacro-iliac Fusion.—In cases where the fusion of only one sacro-iliac joint is required, the surgeon has the choice of several distinct and satisfactory methods. Smith-Petersen's subperiosteal approach to the outer surface of the ilium, with the removal of a rectangular block of ilium and its reimplantation into a socket cut into the sacrum, has been well described and perfected by its originator.

The writer has used it in many cases, and with excellent results. It causes practically no shock, is nearly bloodless, and can safely be recommended. When performed for the first time by the average operator, there is a feeling of uncertainty as to the exact location of the joint, and the cutting out of the block is somewhat trying on account of the great variation in the thickness of the ilium at different points in the operative field. In one of the more recent publications of the originator of this ingenious operation, the use of an electric motor-saw is advised. A motor-saw cannot safely or conveniently be used in this connection, and the thin-bladed osteotome is perfectly simple and satisfactory.

Bilateral Sacro-iliac Fusion.—Where both sacro-iliac joints require arthrodesis simultaneously, the writer has not used the Smith-Petersen technique, because of the fact that, in this series of cases, fusion of the lumbosacral joint was also performed. This combined operation, well termed by Chandler "trisacral fusion", can best be performed through a single transverse incision, convex either downward or upward. The fifth and usually also the fourth lumbar vertebrae are first attacked by the combined method above described, and the sacro-iliac joints are then subjected to either the Chandler or the Campbell operative technique. Chandler's method is mechanically correct, though more complicated and possibly more bloody than Campbell's. Either one is perfectly satisfactory when properly done. Not long ago Verrall proposed a transverse tibial graft placed across the sacrum and inlaid into holes bored into the iliac crests. The writer followed this technique in a single case, and the patient was relieved for nearly a year, when the original symptoms again appeared. At reoperation it was found that the tibial splint had united perfectly to the sacrum and to both ilia, but that a definite torsion or twisting of the splint had developed and could easily be demonstrated by levering the pelvis forward and backward. Both sacro-iliac joints were freely movable, and the graft could be seen to rotate on its long axis in either direction. Campbell's operation was then performed, and the patient states that he is now perfectly well. The writer feels that Verrall's method, as evidenced by this one case, is mechanically unsound, and should be abandoned.

SUMMARY

To summarize the points in this paper:

1. Ankylosis of lumbosacral or sacro-iliac joints will produce rapid relief in cases of pain and disability due to mechanical instability or to disease limited to these joints.
2. The best operative procedure for the lumbosacral region is a combination of the Hibbs technique with one or more large bone grafts removed preferably from the ilium; where great speed is imperative, the original Albee technique is recommended.
3. A single sacro-iliac joint can be satisfactorily fused by the Smith-Petersen technique, or by the Campbell or Chandler method. When both sacro-iliac joints require fusion, or where the trisacral fusion is required, Campbell's or Chandler's method should be combined with the lumbosacral operation above described.

THE CONSERVATIVE TREATMENT OF BACKACHE*

BY LLOYD T. BROWN, M.D., BOSTON, MASSACHUSETTS

The conservative treatment of backache from the orthopaedic standpoint opens up a large field.

Since the spine is made up of a great number of joints, the physiology of which is the same as that seen more easily in the wrist joints, for purposes of description the fundamental principles will be described as they are seen in the wrist.

It is fundamental that as long as the wrist is used within its normal range of motion, there is no strain. When motion is forced beyond one or the other extremes of the normal range, strain may occur. The strongest position, therefore, for the wrist is one approximately half-way between either of the extremes of flexion or extension,—a position, which, in the language of the mechanical engineer, has a factor of safety motion in either direction. If the wrist is held in a flexed or an extended position, there must be a loss of the factor of safety motion. In such a flexed or extended position, any motion toward the nearer extreme will cause a strain on the ligaments of the joint, unless the loss of this factor of safety motion can be

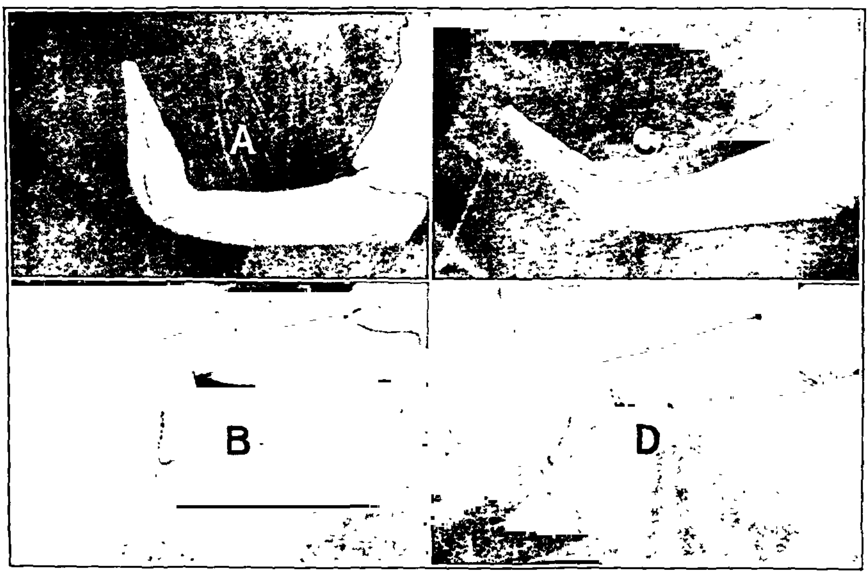

FIG. 1

Wrist 1 Wrist 2

Note the difference in total amount of motion in two normal wrist joints. Position *A*—full extension—could not be assumed by Wrist 2 without injury. Position *C* could be assumed by Wrist 1 with no injury, as there would still be a factor of safety motion.

*Read at the Annual Meeting of the American Orthopaedic Association, Memphis, Tennessee, April 16, 1931.

compensated for by muscular strength or by motion in some other part,—such as the hand, arm, shoulder, or body. Such compensation is always present and is the reason why the average individual does not strain or even break his wrist when he falls on it. It is very important to realize that the amount of the factor of safety motion varies with every individual wrist (Fig. 1). A very loose-jointed wrist (*A* and *B*) used in the optimum position will have a much greater factor of safety than a wrist with only half the amount of motion (*C* and *D*). Therefore, two wrists held in the same degree of flexion or extension may have very different factors of safety and the potential of trouble in one may be slight and in the other very great. One requires little or no compensatory effort to prevent injury and the other requires a great deal.

In the wrist, where there is no weight-bearing strain, the possibility of injury is much less than in a weight-bearing joint,—like the foot, or the spine. The pronated or valgus foot gives a very good example of what happens to joints when the faulty weight-bearing factor is present (Fig. 2). A foot with good weight-bearing lines (*A*) has the full factor of safety motion in all directions; in other words, there is little potential of trouble or injury while used in this position. A pronated or a valgus foot (*B*), on the other hand, since it has lost its factor of safety motion, and since the muscles, because of the bad mechanical position of the bones, must work at more or less of a disadvantage, has a great potential of trouble. Every time the weight comes on such a foot, the strain must be either on the ligaments or it must be compensated for by the knees or back. The pronation or valgus of such a foot, with its lessened factor of safety, by itself may cause no trouble. We all know, however, that such a valgus foot, when once it is injured, recovers much more slowly than a foot with good weight-bearing lines. We all know that after a fracture of the fibula, the strength comes back much more quickly if the foot has been held in a position of at least slight varus during the treatment. It is a common experience that, after a sprain of an ankle, for a long time there will be swelling or thickening around the ankle joints, particularly just in front of the external malleolus. This swelling is nature's reaction

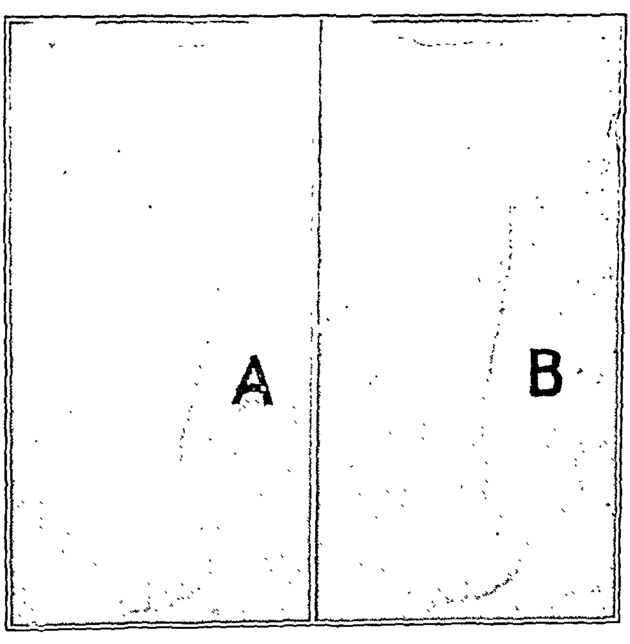

FIG. 2

A. Good weight-bearing line having factor of safety motion in valgus and varus.

B. Poor weight-bearing line having no factor of safety motion in valgus.

to the oft repeated slight trauma due to the habitual use of the foot in faulty weight-bearing lines. It is also known that such a swelling will disappear when the fundamental faults of improper weight-bearing, with the consequent loss of the factor of safety motion, have been corrected.

The fundamental principles mentioned above are:

(1) A joint which is used habitually in a position which has free motion in either direction has a small potential of injury. Such a joint has the so called factor of safety motion.

(2) A joint which has a small or no factor of safety motion has a definite potential of injury.

(3) The best treatment for an injured joint is: first, to correct the weight-bearing lines in order to regain the factor of safety motion; and then to be sure that function is carried out in good weight-bearing lines.

How do these principles apply to the spine and the question of backache? It will be impossible and unnecessary to take up each section of the spine in applying these principles. It is only necessary to discuss the lumbosacral region, because the same mechanical principles are applicable to all regions of the spine.

In the examination of the spine the first point to be investigated is the position in which the joints of the spine are habitually used (Fig. 3). Is there present the normal amount of the factor of safety motion? In good body mechanics (*A*), in the standing or sitting position, the weight of the body is carried on the bodies of the vertebrae with the intervertebral discs acting as shock absorbers. The articular facets act largely as stabilizers; they are not structurally placed or built to support the whole weight of the body. In good body mechanics the articular facets will be so articulated that there will be a factor of safety motion in either direction. In bad body mechanics (*B*), in the standing position, with the usual lordosis in the low lumbar spine, the weight of the body is thrust backward so that it comes on the posterior half of the vertebrae and especially on the articular facets. In such a position the factor of safety motion in the direction of extension must be absent. In the sitting position or in the forward bending position, in bad body mechanics, the weight of the body is changed more to the front part of the bodies of the vetebrae and the articular facets change their positions so that the factor of safety motion in the direction of flexion must be absent. In either of these two positions, extension or flexion, the strain from the weight of the body must come on the joints of the articular facets at the extremes of their range of motion which, as said above, is a potential of injury. This potential of injury, which means stretched and relaxed ligaments, must be compensated for by muscular action or by motion elsewhere in the spine or extremities. If this necessary compensatory action, which is largely reflex, does not function quickly enough—as in lifting or in sudden unexpected motions—there is possibility of acute injury to these joints or to the muscles in this region. Such possibility of injury is, of course, greatly increased if the general condition of the

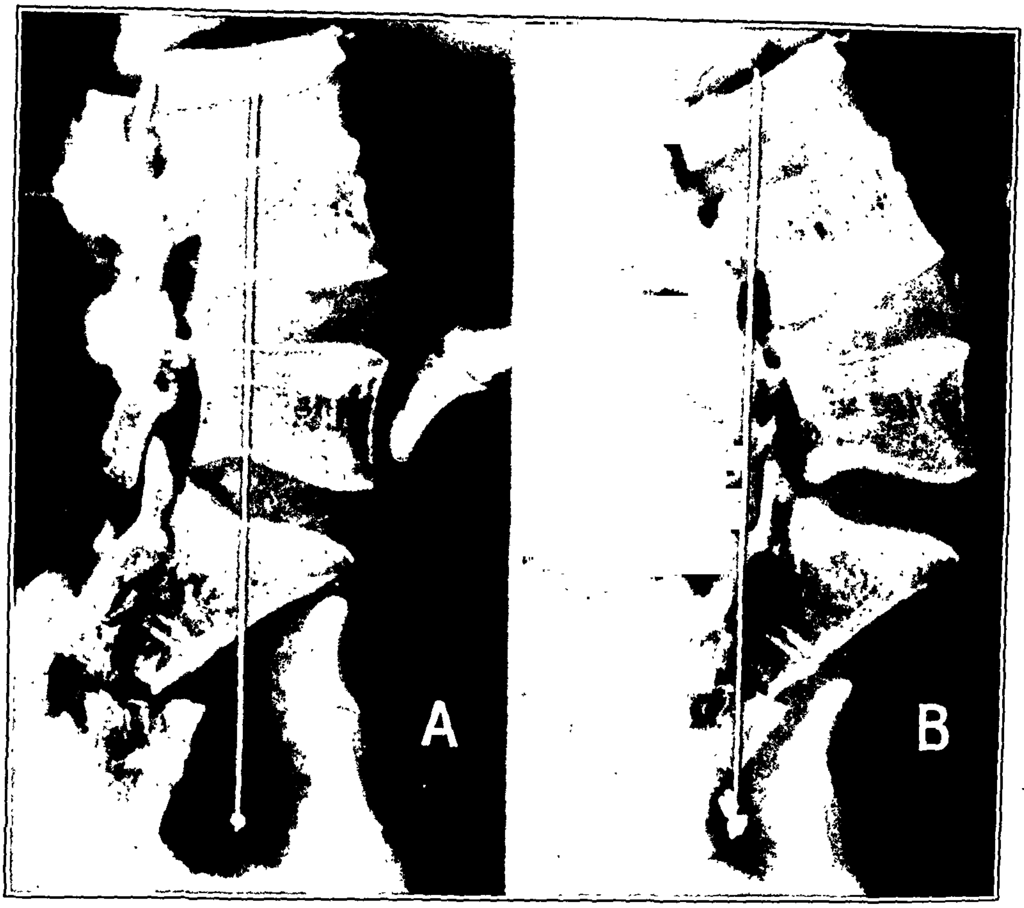

FIG. 3

X-ray of lumbosacral spine.
A. Good body mechanics. Weight carried on the vertebral bodies.
B. Poor body mechanics. Spine in full extension. Weight carried mostly on the articular facets.

patient is one of marked fatigue, or if there is an infection present. The quickness of the response of this compensatory action must also be affected to a greater or lesser extent by the innumerable slight strains caused by habitual faulty body mechanics, none of which strains amount to much, but the sum total of which leads to a chronic state of fatigability.

The anatomy of the vertebrae in the region of the articular facets is particularly interesting from the point of view of symptoms and treatment (Fig. 4). The joints between the articular facets are true joints with capsules, ligaments, and synovial membrane. These joints form a very considerable part of the posterior wall of the intervertebral foramina (*X*). The position of extension (*B*) in the low lumbar as well as in the cervical region decreases the size of the intervertebral foramina (*X*), while the position of flexion (*A*) increases it (*X*). An injury to the joint between the articular processes, therefore, because of the consequent exudative and inflammatory reaction, must still further decrease the size of the intervertebral foramina in the region of the injury. It is, therefore, possible that the combination of the effects of the extreme extension of the lumbar spine, in addition to the swelling from the irritated joint, may cause pressure on the nerves or blood vessels in the intervertebral foramen with the subse-

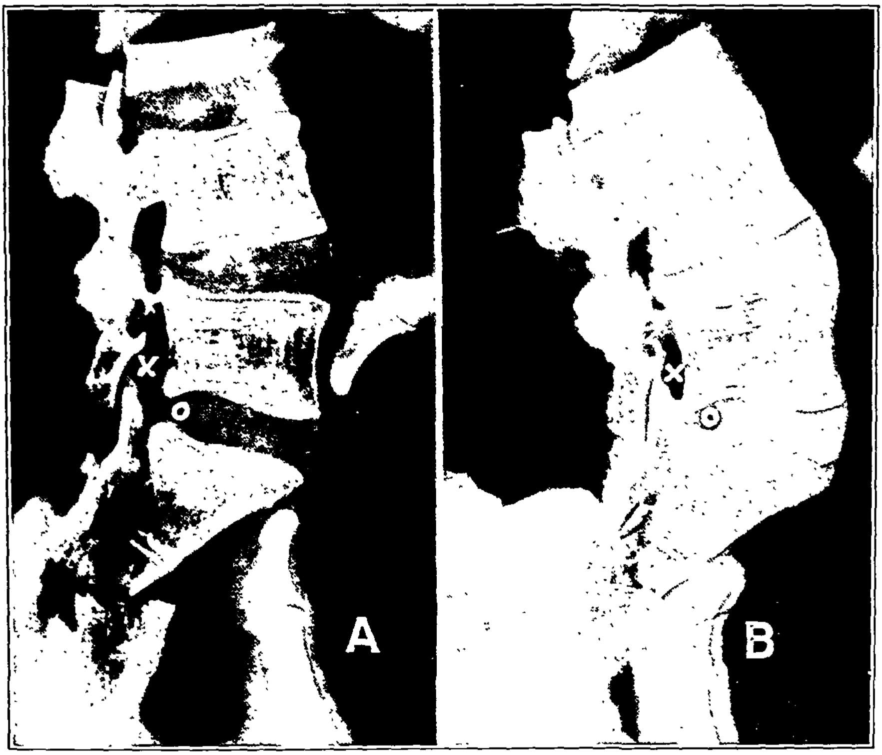

FIG. 4

X-ray of lumbosacral spine.
A. Good body mechanics. *B*. Poor body mechanics.
Note that the intervertebral foramen (*X*) is considerably smaller in poor body mechanics. Note that the intervertebral space (*O*) is narrower posteriorly and wider anteriorly in *B* than in *A*.

quent symptoms of referred pain. As the swelling from the injury may not reach its maximum for some hours after injury, the painful symptoms may not occur for as long as twenty-four hours. The original injury may not have been severe enough to cause more than temporary symptoms but the loss of the factor of safety motion, due to the faulty body mechanics (Fig. 5), makes possible innumerable strains and slight injuries, the sum total of which, added to the acute injury, can fully explain the delayed symptoms. Could these latter slight strains have been eliminated, as is entirely possible by good mechanics or by immediate bed treatment, the delayed symptoms could have been prevented.

The conservative treatment of backache is based on a knowledge of the fundamental mechanical principles stated above. The first requisite of such treatment is rest, and the second is function in the correct position.

In the treatment of a sprained ankle, the combination of rest and function is used as soon as possible after the injury. If the strain is severe enough, the treatment is complete rest until the inflammation has quieted down, followed as soon as possible by function with strapping to prevent further injury. The strapping is always applied to keep the foot from

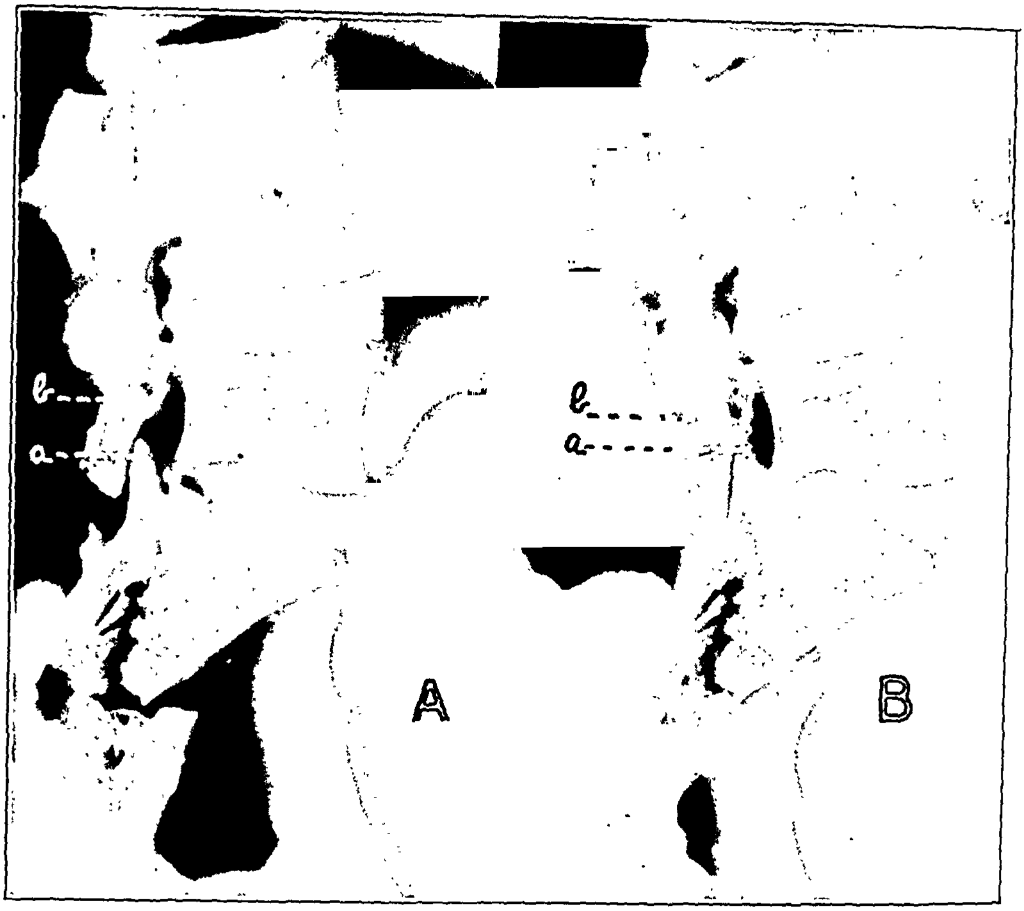

FIG. 5

X-ray of lumbosacral spine.

A. Good body mechanics. *B*. Poor body mechanics.

Note the change in the positions of the articular processes. In extension (*B*) the tips of the articular facets (*a*) are in contact with the bases (*b*) of the opposing process. In *A* there is considerable space between the tips and the bases of the processes. This separation would be much greater in a fresh specimen.

getting into positions which could cause further strain. If the injury is not too severe, immediate function is begun with strapping for protection.

The same method of treatment is equally important and efficient with backache. It is, however, more difficult to carry out and requires more knowledge and patience. The following is an outline of the treatment of a man who had suffered off and on for ten years with pain in the back and alternating sciatica. At first the attacks were infrequent but as time went on they became more common, until he was unable to ride in an automobile or lift anything or at times lean over to put on his shoes without getting a catch in his back. As he was a prominent man, he had had many opinions, the majority of which were for the operative method of treatment.

This picture (Fig. 6) shows the first and most important point in the examination. This man's habitual position of use of his body was at the extreme range of the motions of his spine, particularly in the low lumbar region. It was noted, as is so common in habitual faulty body mechanics, that all of the motions of the spine—particularly flexion—were begun in

the low lumbar region which, of course, puts extra strain on this part; also, when the motions were finished, the body settled back again into its habitual faulty position.

Of equal importance to the story of backache in this man was a long-standing history of indigestion, constipation, headaches, and nervousness, for all of which there had been hospital and sanitarium treatment. The man himself was an unusually intelligent and mentally well-poised individual who realized that his present condition was entirely due to long hours of overwork for many years. Further examination of this man showed a subnormal temperature, a systolic blood pressure below 100 and extreme fatigue. The treatment, accordingly, was planned on the basis of rest and then function. As is not uncommon, this man found it very difficult to stay in bed, as the bed made the back more uncomfortable. Nevertheless, as recumbency is the only way possible to take the weight off the vertebrae and get complete rest, it was the doctor's job to make this position possible. This can usually be done by placing one or two pillows under the knees, thus flexing the hips enough to take the strain off the lumbar spine. This position, of course, can be varied by lying on either side or on the face but the sitting or erect position should be avoided, as it mechanically must put strain on the already strained ligaments or muscles. The face position which tends to cause extension of the lumbar spine may be very uncomfortable, making it necessary to use two or more pillows under the hips in order to obtain sufficient flexion of the thighs. It is a valuable position, however, as it allows the use of hot fomentations to the back to relieve the pain and the inflammation.

Along with these positions the patient was immediately started on abdominal and breathing exercises, all of which were the first steps in the postural education which would fulfil the second fundamental principle of treatment,—namely, function with the best weight-bearing lines. As soon as possible the stretching out of the dorsal spine and ribs was begun by means of the hyperextended position, as it is obviously impossible to acquire the correct body mechanics by treating

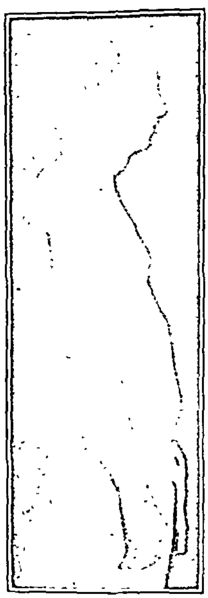

FIG. 6

Photograph of patient before treatment. Note that the low lumbar spine is in the habitual position of full extension. Note also the poor mechanics of the rest of the body.

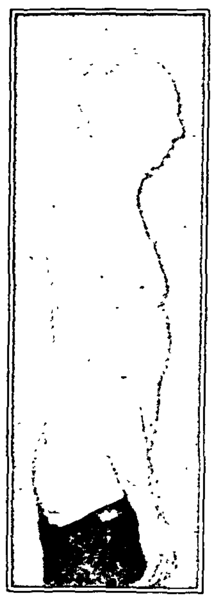

FIG. 7

Photograph of patient after treatment. Note the change in the position of the lumbar spine. Note also the improved mechanics of the rest of the body.

only one part of the body. The next step was the problem of teaching the patient how to use his body in good mechanical alignment when up and around. It would scarcely be possible for such a person, particularly a tired-out patient, to hold himself correctly without some support; and so a brace was planned which, although it could not hold him in the correct position, would help him to so hold himself. This brace was planned not only to give support to the pelvis, lumbar spine, and abdomen, but also to give support to the lower half of the dorsal spine. The reason for this latter support was to put the weight of the upper body more on the front of the lumbar vertebrae and less on the articular facets. The exercises in the meantime had gradually been changed so that the patient had now been shown how to use the body more correctly in the sitting, standing, and bending positions. This picture (Fig. 7) shows the man after he had learned his lesson. His backache and indigestion and other symptoms had cleared up; but as his temperature was still subnormal, and his blood pressure too low, and as he still tired more easily than he should, he could not be considered as entirely cured. It was a relatively easy task to relieve the backache but it will take time to overcome the long-standing fatigue.

From the above outline it can be seen that the conservative treatment of backache consists, not only of treating the back, but also of treating the patient himself. With the above patient the back was only one of the places where the body machine had given way under the combined strain of overwork and faulty body mechanics.

There is no doubt that the disability due to acute back strains, so many of which become chronic, could be very much lessened if the treatment for the back strains could be started immediately after the injury, and if the fundamental principles of conservative treatment were properly carried out. The first principle is rest and this means that the whole body must be put into a position which, mechanically, gives the greatest amount of rest even though, at the outset, it may be difficult for the patient to take such a position. The second principle is function, as soon as possible; but the function must take place with the body in the best possible mechanical alignment. This can only be accomplished by education under the supervision of a medical man who understands what is required for each individual patient.

BACKACHE FROM THE INDUSTRIAL STANDPOINT*

BY PAUL B. MAGNUSON, M.D., CHICAGO, ILLINOIS

Before considering backache from the industrial standpoint, it seems to me, from a rather extensive experience in examining injured workmen, that the mental attitude of the examiner at the start of the examination must be as carefully analyzed as the mental attitude of the patient at the time of examination. In other words, it seems important that the examination be made with the idea of finding what, if anything, is the matter, rather than with the idea of proving or disproving that there is or is not anything the matter.

Pain in the back which is claimed to be due to injury has been a disputed point at law for many years. Attorneys, employers, and workmen have had their choice of physicians to prove their own points, which would seem to indicate, to an impartial observer of the proceedings, that the causes of backache are so obscure and the objective symptoms so difficult to demonstrate that there is always a chance for an argument, and that frequently the most plausible and glib witness on either side is the one desired. Therefore, before we start to examine backs, let us examine our own mental attitude. We are not examining for an employer to prove his point, or for an injured man to prove his contention. We are making an effort to determine whether there is pain in the back, whether this pain could be due to the injury claimed, or whether it could be due to the injury claimed plus some preexisting condition, or whether it is the result of something inherent in the patient's body which has caused pain in the back without injury.

With these points clearly in mind we become diagnosticians, not partisans in a lawsuit. Medical men if anything should always be impartial. They should have good reasons for any statements advanced, and should be able to back up these statements with findings which can be substantiated. On the other hand we must not forget that we are human, that we do not know all the things that can happen and why all the things do happen to the human mechanism that may give pain, and that in the back especially there is a complexity of anatomy which makes careful analysis as necessary as acute observation. It would seem necessary, too, that a man who examines a back from the industrial standpoint should have had much experience in examining backs in private practice, because of the psychological differences in the two classes of patients. The patient who comes to the doctor and pays a fee for an opinion and treatment, usually lays all his cards on the table face up. He comes with the idea of telling the truth and the whole truth, with nothing held back or covered up, because he is seeking relief from his symptoms. The doctor, therefore, is

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able to judge whether the symptoms complained of are real, and to fit the physical findings to the symptoms, thereby gaining knowledge of the problem which cannot be gained from a one-sided examination.

In my experience the true malingerer is infrequent in industrial practice. It is true that many patients exaggerate their symptoms. This is on the same basis that the claims department and the company surgeon minimize the symptoms. The patient is simply starting with a high bid, as the company is starting with a low bid, so that a fair adjustment may eventually be reached.

We must have in mind also that the claims department depends on us for information. If an examining physician says that an injured workman is exaggerating his symptoms or malingering, the claims department can only follow the advice of the man in whom they have confidence—the doctor—and many injustices have been wrought on this side of the case as well as on the other side. Fairness, justice, and honesty in these examinations, with the benefit of the doubt thrown in the patient's favor, it seems to me, is the only fair mental attitude. In all my industrial experience, which was ended several years ago but which for fifteen years was fairly extensive, I have never come in contact with an employee of a corporation who did not keep his agreement to stand by the opinion rendered in an examination. It is true they want to be as sure as possible that the opinion is correct and, if they get conflicting opinions from different medical men, it is only natural that some doubt is raised in their minds. Therefore, in reporting examinations, especially in back cases, the examiner should set down definite reasons for his findings—whether for or against injury—and analyze the case so that the attorneys who read the report will know what the doctor's mental processes are and why he has arrived at certain conclusions. By this, much misunderstanding can be avoided and harmony can be promoted between employer and employee; many times harmony is disrupted by conflicting medical opinions.

THE EXAMINATION

The system of examination which has been developed after many back examinations may be of interest. The clothing is removed. With the patient standing with both feet squarely together and the arms at the sides, note is made of whether there is any abnormal curve in the spine, or any deformity. Muscle spasm is looked for and the back muscles are felt from top to bottom to see whether there is any difference in tone. The patient is then asked to bend to the right, and this includes bending of the head to the right. It is noted whether the curve begins at the lower part of the spine and whether there is any segmental limitation of motion.

The patient is asked to put one finger on any point of pain that he may have, and this point is marked with a skin pencil. The opposite motion to the left is then requested, the above points noted, also whether there is

any difference in the curve of the spine at any point or as a whole, and whether there is any difference in the total degree of flexion on opposite sides. The patient is again requested to indicate with one finger any points where there is pain. Flexion obliquely to the right and then obliquely to the left are then requested, and again observation of the curve, muscle spasm, and indication of points of pain are noted.

These motions are reversed and the patient is requested to hyperextend backward to the right and then to the left, and the same questions are asked; then straight forward flexion and straight backward hyperextension. All the indicated points of pain are noted on the examining chart and all the points of pain are marked on the patient's skin.

We then start at the top of the spine and with the thumbs or fingers, preferably the thumbs, go down the spine over the spinous processes and then on each side of the spinous processes, asking the patient to state when a tender point is reached, and the tender points are again marked with the skin pencil—in a different color this time—and the findings are noted on the chart.

The general physical examination is then started. The nose, throat, teeth, heart, lungs, abdominal viscera and prostate are gone over and the history of the case carefully taken. The patient's habits are gone into, the amount of food, the kind of food; the other joints of the body are examined to see whether there is any enlargement or signs of arthritis. Then the patient is requested to stand again and the examination of the back is repeated, notation being made as to whether the points of pain and tenderness correspond to the previous examination. It is a well known fact that an injury to a muscle, tendon, joint, nerve, or other tissue does not move; and it can be safely assumed, therefore, that even in the absence of very marked objective signs, if the patient has pain where he says he has on first examination, it will appear reasonably close to that point on the second examination. Slight variation of course can be made, but when the points do not check up reasonably well a suspicion may arise.

The patient is again requested to be seated, or an examination of some other part of the body—usually the reflexes and feet—is made and noted on the chart. Should the second examination seem to vary much from the first, it is well to use what I call a pressure meter to estimate the amount of tenderness in the various points complained of. This instrument was devised to register in pounds

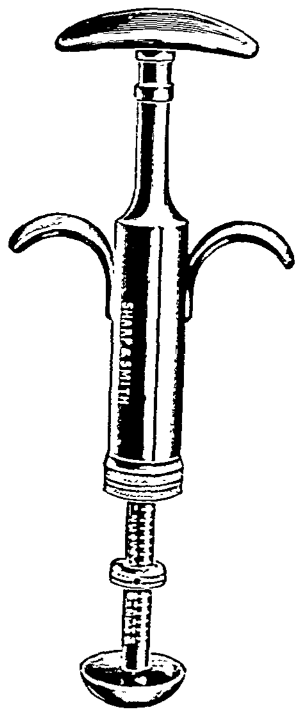

FIG. 1

Pressure meter, an instrument for measuring sensibility to pain in examinations of the back.

the amount of pressure put on the instrument. It is simply a spring-scale plunger with a padded ball on the end, the pressure being recorded by a sliding ring which remains in place after a given amount of pressure has been put on the ball.

In the third examination of the back, the tender points that have previously been marked are recorded and the number of pounds of pressure which causes pain. If there is a complaint of pain on one-half to one pound pressure, it would seem reasonable to suppose that the point was extremely tender and yet, if this point varies from time to time in its location or if the patient can put a stretch on the tissues involved in such a tender point when he flexes, without exactly locating this tender point, it may be assumed that it is not as tender as the patient says. If the examiner is forceful and entertaining and inquisitive all at the same time, the patient's attention may be diverted. For instance, the examiner can examine one part of the body with one hand, focusing the patient's attention to this point, and at the same time can put the pressure meter over a spot which on previous examination elicited a complaint of pain on one-half pound pressure, and if, with the patient's attention diverted, the operator finds that he can put twelve or fifteen pounds' pressure on this point without complaint from the patient, then again one may assume that it is not as tender as the patient claims it to be. In other words, if the examiner realizes that certain muscles are put on a stretch with certain definite movements, that certain joints have pressure exerted on them with certain other movements, that some movements bring out tenderness in muscles and ligaments and others in joints and nerves, it is not a difficult matter to make a deduction as to whether there is real pathology or not, in spite of the fact that there are no casual objective symptoms.

On the other hand, we must remember that there are two separate and distinct groups of ligaments in the lower back: one anterior to the spine, which cannot be felt from the posterior surface, and which will not give tenderness but will give pain; and the posterior group, which can be felt, although also covered with a heavy layer of muscles and attachments. Through these anterior ligaments and over them run the lumbar and sacral nerves; and an inflammatory condition, which may be purely traumatic, or traumatic plus infectious, or toxic, will cause pain without giving any tenderness. The inflammatory conditions in the anterior ligaments and joints, in my opinion, give more symptoms of referred pain down the legs than those in the posterior.

There are other causes to be looked for in these cases of industrial back pain—the patient's age, his general state of health—and when I say age I do not mean years, but the age of his joints and ligaments, which may have aged much faster than his years because of hard labor, poor food or the wrong kind of food, poor elimination, exposure, infection, or toxaemia which have not been taken care of. It must not be overlooked that many of these patients have toxaemia, either intestinal or metabolic, and many of them have chronic infections; that muscles and ligaments and bones immediately in contact with the attachment of muscles and ligaments, as well as joints, are favorite places for the production of infection and toxaemia; that when this occurs the elasticity of the muscles and ligaments

diminishes and they are more easily injured, and when injured the disability lasts longer than it does with normal tissue.

In my experience, the great majority of patients who have back pain of any magnitude as a result of comparatively slight injuries are over forty years of age, the time when the wear and tear of life is beginning to tell, and we should not approach these cases as bone and joint men but as diagnosticians, because examination of the whole organism is necessary to determine the causes and remove the contributing factors. My experience has shown that diet, a large increase in fluid intake, elimination through the bowels, skin, and kidneys, and rest of the injured part are important considerations in the treatment of these cases. When I say rest I do not mean simply not working, I mean the real rest that comes from a horizontal position, because the lower back is a fulcrum upon which every motion of the body takes place. The body above this point is one arm of the lever and below is the opposite arm of the lever, and no cast or brace can remove the weight that is carried or prevent the shocks that are sustained by the lower back in any kind of motion in an upright position. The ligaments in the back are not different from the ligaments in any other part of the body, except that there are more of them and they have more work to do, and they should be treated in the same way that any other injured ligaments are treated. The fact that some arthritic process shows around the edges of joints does not mean that the back is not injured. It does demonstrate the existence of an inflammatory process for some time, and, because of this, the ligaments supporting the back have had toxic material deposited in them over a period of time and are, therefore, more liable to injury than are the normal.

The interpretation of x-rays in these cases of industrial backache has been the cause of many bitter arguments. I have stated before and will state again that the reason the clinician many times does not make a diagnosis in cases of backache is because the roentgenologist will not tell him what is the matter with the patient. The x-ray is of minor importance in a large percentage of cases in the diagnosis of backache and its causes. There are few individuals who have suffered any of the consequences of living who do not have some evidence of so called arthritis in the spine. We all know that there are many individuals doing daily work with spurs on the joints of the spine or elsewhere. If x-rays of these cases were held up for examination, the patients would be considered unfit for any sort of labor, and yet they have no symptoms. On the other hand, acute inflammatory processes in bones, joints, or ligaments do not show. The fact that such a condition shows on the x-ray means that it has been there for a long time and, if the patient has been working for many months, it is certain that he has been working with the same condition that is shown on the x-ray. Therefore, the condition which is causing the trouble must be a more or less acute affair.

In the final analysis, therefore, the man who examines the patient with a backache, which it is claimed comes from some injury, must be a diagnostician of the highest order, not looking at the back alone, but taking into consideration everything which might cause pain in the back, and evaluating

CONGENITAL ELEVATION OF THE SCAPULA

(Sprengel's Deformity)

BY ROBERT PATTERSON, M.D., F.A.C.S., KNOXVILLE, TENNESSEE

The author has seen very few reports of successful operations upon adults for congenital elevation of the scapula (Sprengel's deformity).

The following case report is submitted as an example of what may be accomplished in extreme cases of this deformity by operation and physiotherapy.

Arthur S., aged twenty, presented himself for examination May 2, 1931. He had a marked deformity of the left shoulder and chest which he attributed to a fall at the age of six, in which he sustained a glenoid fracture.

Examination showed a typical Sprengel's shoulder on the left side, which was elevated two inches or more above the right shoulder. The latter appeared to be higher than normal. He had a very thick neck transversely. He could easily touch the top of his shoulder with the side of his neck. Both clavicles were comparatively straight but prominent, and the upper chest was depressed. He had normal movements of the arm at the shoulder, but all of those in which the scapula participated were absent. There

FIG. 1
Patient before operation.

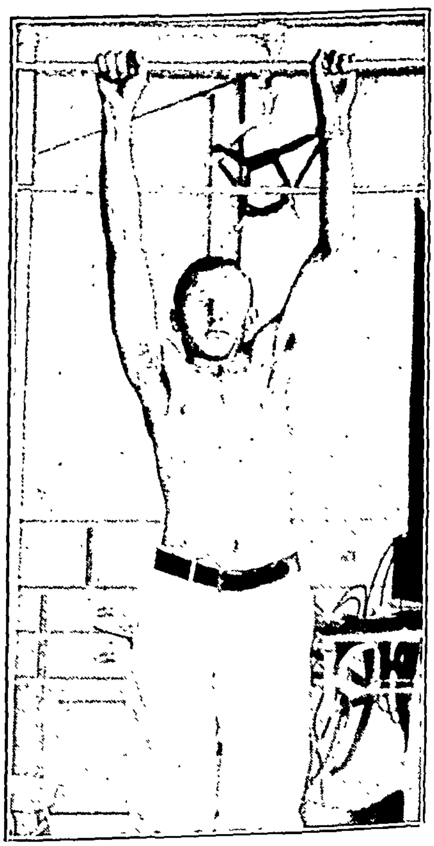

FIG. 2
After operation.

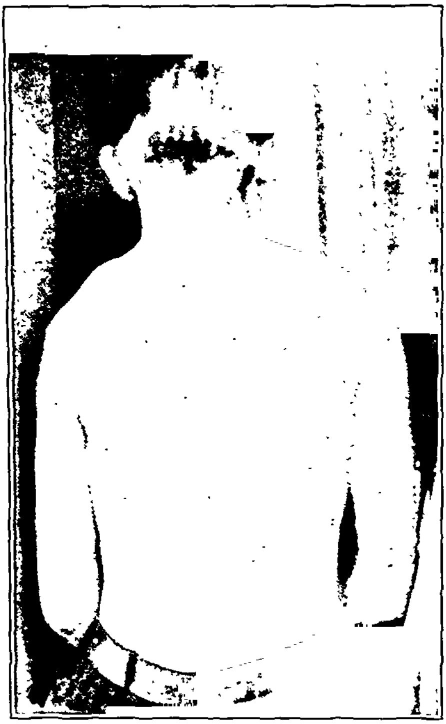

FIG. 3
Posterior view after operation.

FIG. 4
Anterior view after operation.

was no movement of the scapula. The upper and posterior edges stood out prominently and a bridge of bone was felt extending from the upper inner angle of the scapula to the region of the seventh cervical spine to which it was firmly united. The deformity was most unsightly. He sought relief for this reason and because it was hard to get clothes to fit on account of the projecting bone. In addition to being elevated, it presented somewhat the appearance of a "wing scapula".

Operation was performed on May 22, 1931. The incision extended from the lower angle along the posterior border, curving outward over the supraspinous fossa; another extended from this along the bridge of bone to the neck. The scapula was severed from all structures along the posterior border, and the bridge of bone was freed and removed. This bone appeared to be an extension outward of the angle of the scapula and was one and three-quarters inches wide at the base and tapered off to one inch at its insertion into the spinous process.

The supraspinous muscle was then elevated and the bony fossa exposed. This was found to bend anteriorly, forming almost a right angle to the rest of the bone. It was removed back to within one inch of the suprascapular notch and nerve. The infraspinatus muscle was elevated subperiosteally from the vertebral border, likewise the subscapularis and the seratus magnus beneath. The entire prominent portion of the bone, which was more than an inch thick in one place, was resected. The scapula could then be depressed somewhat.

The romboids were practically absent. There was a round bundle of muscle above and one below the bridge of bone running in the same direction,—evidently a portion of the trapezius. Very little muscle tissue was apparent between the scapula and spinous processes. There was a thick fascial layer. Physiotherapy was begun three weeks after operation and was continued for about seven weeks.

Results: Shoulder movements on July 28, 1931, were as follows:
Abduction, about 100 degrees;
Forward flexion, about 145 degrees;
Backward extension, same as other arm.

Patient can grasp an overhead bar placed twelve inches above the head and twelve inches in front of his body.

The most interesting feature of the case is the fact that the scapula has seemed to gradually descend to its normal position as muscle training has progressed, until at present both scapulae are apparently on the same level.

The scapula moves through about two-thirds of the normal range. The patient is now able to swim and engage in other activities which were impossible before operation.

SPINDLE-CELL SARCOMA OF TENDON SHEATH

Report of a Case*

BY MORRIS B. COOPERMAN, M.D., PHILADELPHIA, PENNSYLVANIA

Although the spindle-cell sarcoma is a relatively common tumor, widespread in occurrence and developing in any situation where connective tissue is found, its origin in a tendon sheath is so unusual that the writer feels justified in reporting a case that recently came under observation.

Tendon sheath sarcomata are rare neoplasms, 107 cases having been reported up to the present time. The majority of these cases, however, belong to the giant-cell variety, a benign tumor which has been fully described by French and German observers under the terms xanthosarcoma and myeloma. Torneaux, in 1913, collected ninety-three cases from the literature; fifty-four of these were of giant-cell sarcoma. Janik, in 1927, added fourteen new cases recently reported; most of these were giant-cell tumors. From a statistical standpoint, therefore, the spindle-cell sarcoma is less common than the other variety. A rather extensive discussion has centered around the latter because of its peculiar histologic and chemical characteristics, in which trauma and some peculiar disturbance in lipoid metabolism seem to be the exciting factors. It is of interest to note that a number of authors deny the neoplastic quality of this tumor and regard it as a form of granulation tissue (Fleisig, Broders, and Albertini).

The spindle-cell sarcoma of a tendon sheath occurring in adults is a relatively benign growth, particularly when it is encapsulated.

The case under discussion occurred in a young woman after a minor injury to the foot. The tumor, originating in the tendon sheath of the flexor brevis digitorum, was of about eight months' duration.

M.U., female, aged twenty-one, occupation—salesgirl, entered the Mt. Sinai Hospital November 24, 1930. Her chief complaint was swelling of the right foot and inability to bear weight. About a year previously she sustained an injury to the right foot by falling from a ladder, a distance of about three feet. Very little attention was paid to this injury, but several days later she began to complain of pain and stiffness in the foot and ankle which was treated by strapping. Two months later she noticed a small growth underneath the outer border of the right foot which was tender to pressure and painful on walking. Various treatments were instituted without affording her very much relief. Her disability increased and the tumor grew larger. She continued at her work but found it more and more difficult as time went on.

An x-ray examination, five weeks prior to her admission to the hospital, showed a soft-tissue tumor but no bone involvement. Two weeks prior to admission an incision into the tumor was made and a small amount of thick, creamy substance was evacuated. Following this procedure the tumor became irritated, completely disabling the patient. Previous medical and family history are unimportant.

*From the Orthopaedic Service of the Mt. Sinai Hospital of Philadelphia.

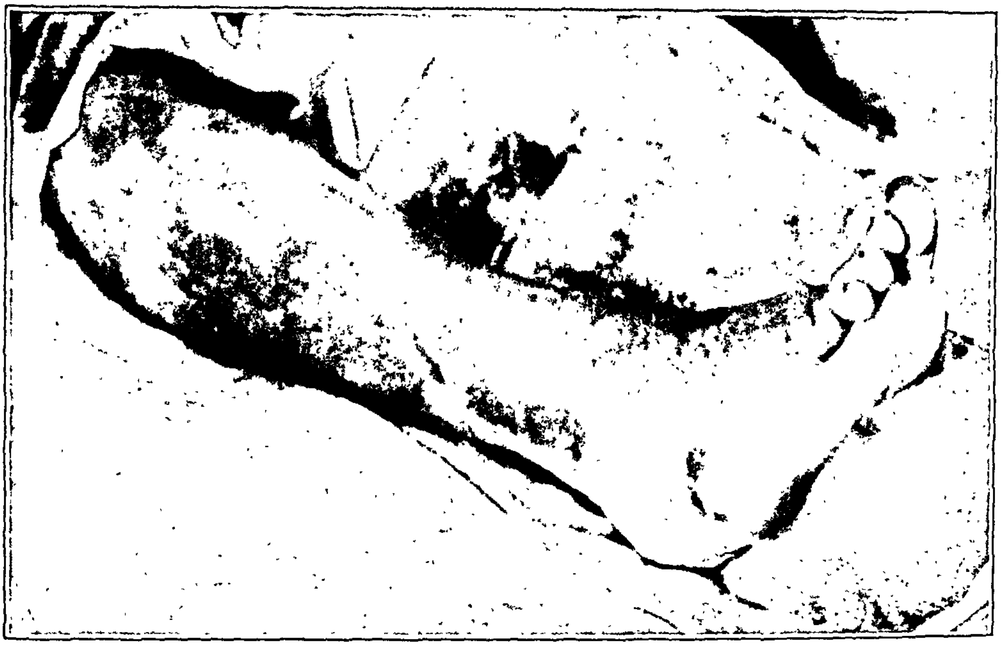

FIG. 1
Spindle-cell sarcoma of tendon sheath.

FIG. 2
Showing the tumor on lateral aspect of the foot. Note the encapsulation and its point of attachment.

FIG. 3
Tumor has been removed, exposing the tendon from whose sheath it originated.

The laboratory studies were negative and the physical examination revealed nothing abnormal, except that the right foot was deformed by a pear-shaped tumor about the size of a hen's egg, located on the outer aspect. Tracing its outline, it was found to extend beneath the plantar surface, approximately, involving the outer half and encroaching upon the transverse arch. It also grew over the outer border upon the dorsal surface. It was soft and elastic in consistency, fairly well circumscribed, not adherent to the skin, but appeared to be firmly attached to the plantar ligaments from which it could not be dislodged. Over the apex of this tumor there was an area of tissue necrosis, about one centimeter in diameter, with grayish base and ragged edges. This ulcer was the site of the incision. The superficial veins on the dorsal surface of the foot were dilated. The ankle, tarsal, and toe joints were normal. The lymph nodes of the inguinal and popliteal regions were not enlarged.

On November 26, 1930, under nitrous-oxid oxygen anaesthesia, with a tourniquet above the right knee, an incision was made along the lateral border of the right foot, extending from the little toe to the calcaneocuboid joint. Upon retracting the skin and subcutaneous tissue, a grayish-yellow, encapsulated and lobulated tumor came into view. It was irregularly oval in shape and was found to originate from the outer layer of the sheath of the flexor brevis digitorum of the little toe. The tendon itself was not involved, but was surrounded by the tumor mass, which measured, approximately, eight by four by three centimeters. The encapsulation was not well defined beneath the plantar muscles and ligaments of the foot. The tumor was shelled out without much difficulty; the tendon and redundant skin were excised and the wound was thoroughly curetted.

Bleeding was controlled by ligature and hot saline packs. The wound was closed in the usual manner with interrupted catgut sutures; a few strands of silkworm gut were inserted for drainage and a plaster cast was applied from the toes to the knee.

The postoperative course was uneventful, the wound healing by primary union in two weeks. The patient remained in the hospital until December 12, 1930. In view of the histologic findings she received seven deep roentgen-ray treatments after the operation.

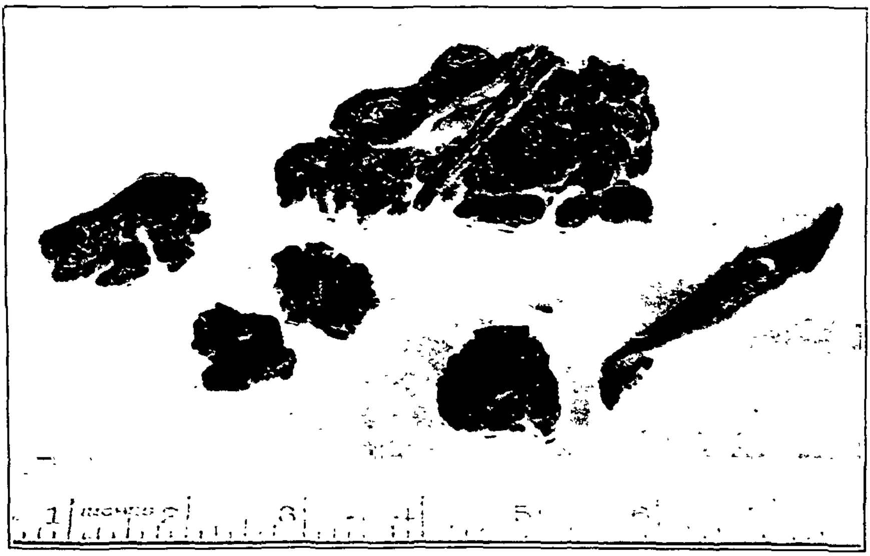

FIG. 4

Tumor and part of tendon with redundant skin. Note the relation of the tumor to the tendon. The largest specimen is the tumor, the others are pieces of plantar fat.

Pathologic report by Dr. B. Gouley. "Macroscopic: One part of the specimen consists of a tendon, five and five-tenths centimeters in length; the second specimen is an elliptical piece of thick, white skin, measuring nine and five-tenths by two centimeters; the third specimen, apparently the tumor, consists of an irregularly oval mass, measuring eight and five-tenths by four by three and five-tenths centimeters, grayish-red in color and encapsulated. On the surface is seen a considerable amount of fatty, lobular tissue which is adherent to a yellowish-white, underlying, firm tissue of semigelatinous consistency. In many areas this tissue shows discoloration as if produced by extravasation of blood.

"Microscopic: Numerous sections of the tumor growth show a uniform, rapid, fibrous hyperplasia invading the surrounding tissue. The cells are moderately enlarged and cell division is noted. In many fields the growth is extremely rich in spindle cells, so closely packed as to make any stroma present appear negligible. Other fields show a fine reticulum, but no myxomatous change is noted. The blood vessels are not numerous but those present are definitely abnormal, exhibiting very thin walls. Giant cells and xanthoma cells were carefully searched for but not found. Pathologic diagnosis: Spindle-cell sarcoma of moderate malignancy."

This slide was reviewed by several other pathologists and they concurred with this opinion.

This patient has been observed in the past eight months and her condition is excellent; there is no local recurrence. X-ray of her chest for metastasis is negative. She has gained in weight and is at the present time in excellent health.

EPIPHYSITIS OF THE PROXIMAL EPIPHYSIS OF THE FIRST METATARSAL AND OF THE FIRST PHALANX OF THE BIG TOE; COINCIDENTAL PRESENCE OF PROXIMAL OR PSEUDOMETATARSAL EPIPHYSES

Report of a Case*

BY M. S. BURMAN, M.D., AND M. POMERANZ, M.D., NEW YORK, N. Y.

The epiphyses for the metatarsal bones appear usually at four to five years of age, that of the first metatarsal appearing first, and being placed proximally at the base of the bone, those of the remaining four at the heads of the bones. Fusion takes place at about the seventeenth to the eighteenth year. Occasionally, and with sufficient frequency so as not to be rare, epiphyses are noted at the bases of the other metatarsals, those for the second and fifth metatarsals being seen most often. These accessory or pseudo-epiphyses, as they are called by anatomists, may be regarded as having no particular significance, save that of an interesting anomaly, or they may be considered as evidence of retarded ossification, endocrinally arisen. Köhler notes that these proximal epiphyses are always present in man in the primitive formation, but that fusion takes place early with the ossifying diaphysis.

Disease of the basal epiphysis of the first matatarsal has been seen only once. No observation of disease of the pseudo-epiphyses has been reported. Wagner noted an isolated, aseptic necrosis (epiphysitis) of the proximal epiphysis of the first metatarsal, the etiology, as usual, being assumed. He failed to comment on the similar change in the proximal epiphysis of the first phalanx of the big toe bilaterally. One of us has observed in the last few years at least six cases of similar changes in the proximal epiphysis of the first phalanx. The case here presented shows bilateral disease of the proximal epiphyses of the first metatarsals and first phalanges of the big toe (epiphysitis), associated with proximal or pseudo-epiphyses of the second, third, fourth, and fifth metatarsals, bilaterally. The association is most probably incidental, and not significant.

CASE REPORT

Case B 10022, M.H., a boy, aged four, was seen in the Out-Patient Department of the Hospital for Joint Diseases, May 20, 1930, because of pain and swelling of the feet. The patient had had a tired feeling in his feet for two years and could not walk distances well. In the past two months, he had had occasional pains in the feet, and transient swelling of the heels and ankles, more marked on the right side. These swellings had been noted also in the lower lip, in the lower part of the left ear, etc., and were sometimes accompanied by a skin rash, which usually followed the oral administration of

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Fig. 1-A
Anteroposterior view of feet of patient described in text. X-ray taken May 21, 1930.

aspirin or sodium salicylate. There was no history of injury. General examination was negative, except for the presence of hypertrophied tonsils and a loud systolic murmur at the apex of the heart, transmitted to the axilla. Temperature and pulse were normal. The child appeared in good health. The child walked naturally, with no limp. The feet were slightly pronated, with some toeing-in on walking. All motions of the feet were normal. No swelling of either foot was seen. There was no pain and no tenderness anywhere in the feet, and very definitely none over the bases of the metatarsals.

A blood Wassermann and a tuberculin test were not done.

Roentgenographic findings. The first set of x-rays, taken May 21, 1930, showed the presence of the proximal epiphyses of the metatarsals bilaterally, at the bases of the second, third, fourth, and fifth metatarsals. These were partly fused to the diaphysis and showed no sign of disease. The distal or normal epiphyses, at the heads of the metatarsals, were also present, but less distinctly seen; that over the second metatarsal head was seen divided in two, on both sides. The proximal epiphyses of the phalanges were all present. The development of both scaphoids was normal, and no disease process was present in them. Our interest centered about the proximal epiphyses of the first metatarsals and of the first phalanges. The phalangeal epiphyses were compressed anteroposteriorly, the interarticular distance being increased. Definite condensation, with little rarefaction, was noted,—a process similar to Köhler's disease of the scaphoid. The epiphyses were seen poorly in lateral view.

FIG. 1-B
Lateral view taken May 21, 1930.

The proximal epiphyses of the first metatarsal showed greater change bilaterally. The epiphyses were wider externally, narrower internally, and compressed anteroposteriorly, more so on the inner side. A definite line of constriction was noted, more on the right side. Condensation of the epiphyses, with slight rarefaction, was present. There was early fragmentation of the inner part of the right proximal epiphysis. The interarticular distance was increased. Laterally, the changes were also well demonstrated.

Another set of plates, taken June 12, 1930, showed the disease process advancing, especially on the inner half of the proximal epiphysis of the right first metatarsal bone.

The patient, during the brief period of observation, was given baking and massage treatments, and corrective shoes were worn. Rest was advised. Little improvement resulted. The mother noted on her second visit that he still complained of pain at times, and that he could not walk distances well. Continuance of treatment was advised and the mother told of the probably self-limited nature of her child's illness.

Examination on April 1931, showed some subsidence of the disease process. The epiphyses of the proximal phalanges of the great toes were somewhat larger and showed a definite diminution in the hypercalcification. The fragmentation in the epiphyses at the bases of the first metatarsal bones had disappeared and the epiphyses consisted of single segments of bone. The osteitis had completely subsided. The accessory centers of

ossification in the distal ends of the second metatarsal bones on both sides had fused and formed one fairly large epiphysis. The epiphyses of the bases of the remaining metatarsal bones showed no essential alteration when compared with the first examination.

This, then, is a case, in an unusual location, of that typical osteochondritic process, known in other sites as Köhler's disease, Perthes' disease, etc.

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GENERALIZED OSTEITIS FIBROSA CYSTICA ASSOCIATED WITH A PARATHYROID ADENOMA

BY T. P. NOBLE, M.D., F.R.C.S., BANGKOK, SIAM

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The association of osteitis fibrosa cystica and parathyroid disease has been recognized for over twenty years, but the discovery by Collip in 1925 of an active parathyroid hormone made it possible to study hyperparathyroidism experimentally. When parathormone—the active principle of the parathyroid glands—is injected into animals, there is produced an increase in the calcium and a decrease in the inorganic phosphorus in the blood, an increased excretion of calcium and phosphorus in the urine, a negative balance of calcium and phosphorus, together with hypotonicity of the muscles. If repeated small injections of this hormone are administered over a period of time, generalized resorption and fibrosis of the bone marrow results.

In 1926 Mandl removed a parathyroid tumor in a case of generalized osteitis fibrosa cystica. Following the operation there was a prompt and permanent clinical improvement. This appears to be the first demonstration of spontaneous hyperparathyroidism, and is all the more interesting in that there was no evidence of a tumor by palpation of the neck prior to operation. Since that time several cases have been reported, and extensive reviews of this subject have appeared by Hunter in England, and by Barr and Bulger in America.

The following case shows that this disease occurs in the East as well as in the West.

CASE REPORT

History.—A Chinaman, aged forty, a farmer by occupation, was admitted to the Siriraj Hospital, Bangkok, on April 23, 1929. He complained of pain and swelling of his right arm with inability to lift it. Twenty years before he accidently fell in a crowd and was trampled on. There was no fracture at that time, but since then he had had pain and weakness in the right arm and had been unable to carry on his duties as a farmer. He contracted syphilis many years ago while in China.

Examination.—The patient was thin and anaemic, but was able to get about quite well. The right shoulder drooped and the lower half of the right arm, forearm, and hand were swollen. The arm was held in adduction with the elbow flexed. There was crepitus and preternatural mobility at the junction of the middle and lower thirds of the right humerus, without any history of recent injury. No other bony swellings were detected. The Wassermann and Kahn tests were strongly positive and the urine showed a trace of albumen.

X-ray Examination.—The right humerus showed considerable decalcification and a pathological fracture was present at the junction of the middle and lower thirds of that bone. There were numerous irregular expansions of the cortex of the humerus with cystic formation.

A diagnosis of fibrocystic disease of bone in a syphilitic patient was made and intensive antisyphilitic treatment was started, together with irradiated ergosterol and ultra-violet light. The right arm was fixed in a plaster-of-Paris splint.

May 1929.—X-ray showed the fracture of the right humerus to be slowly uniting.

July 1929.—An oval swelling about the size of a hen's egg and bony in consistency had appeared on the upper third of the right tibia. X-ray showed decalcification of the tibia and fibula with a thinning of the cortex and cystic formation in that area.

August 1929.—At the beginning of the month the patient felt pain in both thighs and began to have increasing difficulty in walking. On the tenth of the month, while trying to lift his left leg over the edge of the bed, spontaneous fracture of the left femur took place.

September 1929.—The right humerus had now united, although the irregular expansion of bone could be felt with egg-shell crackling. On the sixth of this month, while trying to lift his buttocks on the bed-pan, he fractured his right femur.

October 1929.—A fracture again appeared at the original site in the humerus. The patient's general condition remained much the same. The three fractures had not united.

January 1930.—The swellings on the right tibia had become larger and another swelling had appeared on the fourth rib, on the right side at its junction with the cartilage, followed by similar swellings on the skull and phalanges of both feet.

February 2, 1930.—Blood calcium twelve and eight-tenths milligrams per 100 cubic centimeters.

February 18, 1930.—Blood calcium fourteen and two-tenths milligrams per 100 cubic centimeters.

The patient had now become very helpless and so miserable that he had threatened suicide more than once. In view of the increasing cystic formations in the bones, the hypercalcaemia and the failure of the fractures to unite in spite of repeated courses of antisyphilitic treatment, the case was considered to be one of hyperparathyroidism due to a parathyroid adenoma, although repeated examination failed to reveal a tumor in the region of the thyroid gland.

November 1930.—Under local anaesthesia the neck was explored for a parathyroid tumor. Both lobes of the thyroid gland were exposed but no parathyroid tumor was discovered, although at a later date the postmortem examination revealed the presence of one. The patient stood the operation well in spite of the difficulties attendant on three ununited fractures. On the third day after operation the patient developed bronchopneumonia and died.

POSTMORTEM EXAMINATION

The body was thin and emaciated with marked atrophy of all the muscles. Two small nodular masses were felt on the ribs. Both femora were fractured with little or no attempt at bony union. On removing the right femur it was found that the head and condyles still maintained their normal appearance; but the shaft, seven and five-tenths centimeters below the neck, had a fusiform swelling, and the compact bone was destroyed and absorbed. Longitudinal section of the shaft showed blood clots in its interior, a small quantity of yellow bone marrow and strands of firm, gray tissue. These were enclosed in gray, fibrous periosteum.

In the neck there was an oval, encapsulated mass which measured two by one and eight-tenths by one and five-tenths centimeters and was loosely attached to the upper and posterior aspect of the left lobe of the thyroid gland. On section it appeared to be a parathyroid tumor which was composed of gray tissue in the upper part and soft, yellow tissue in the lower part. The thyroid was normal in position, size, and consistency. The trachea and oesophagus were normal.

The right lung weighed 315 grams and showed slight oedema. The lower lobe contained irregular areas of gray consolidation. The left lung weighed 460 grams, was oedematous, and on section presented many small grayish elevated firm areas.

The right kidney weighed 105 grams, the cortex had an irregular gray area of scar tissue to which the capsule was adherent. The medulla and pelvis contained a few small calcified masses. Left kidney weighed 100 grams and showed similar lesions.

Microscopic Examination.—The character of the cells of the parathyroid tumor was of three types: First, the normal parathyroid tissue cells were seen in irregular patches here and there. These cells were round, regular in size, and had pale pink, finely granular cytoplasm. The fibrous tissue supporting the blood vessels was thin and moderate in quantity. There were irregular spaces of variable size, lined with endothelial cells and filled with pink-staining homogeneous coagulated fluid. The second type was composed of polyhedral and cuboidal cells, larger than normal parathyroid tissue cells; their cytoplasm was abundant, coarsely granular, and strongly acidophilic. The nuclei were usually round, vesicular, and occasionally showed hyperchromatism, but presented no evidence of mitosis. These cells were closely arranged into irregular anastomosing columns, supported by a moderate amount of fibrous stroma containing blood vessels. At one point they secreted pink-staining homogeneous material in which were a few crystals of cholesterin. The third type consisted of intermediate cells continuous on the one hand with the normal parathyroid tissue and on the other with the adenomatous tissue. They differed from normal parathyroid tissue cells in that their cytoplasm was more granular and they stained more deeply with eosin. In places the tissue was separated into nodules by thick bands of partially hyalinized connective tissue, here and there infiltrated with yellowish-brown granules. Sections of the ribs were made without decalcification and presented no difficulty in cutting. They showed complete replacement of bone marrow by vascular connective tissue, hemorrhagic in places, and infiltrated with mononuclear cells containing black pigment. Among the connective-tissue cells were many large multinucleated cells suggestive of osteoclasts. In some places these giant cells lay very close to the surface of the bone which contained little or no lime salts.

DISCUSSION

Up to date seventeen cases showing the clinical characteristics of hyperparathyroidism have been described. In twelve of these cases a parathyroid tumor was removed; in two, one or more histologically normal parathyroid bodies were removed; in three, no operation was performed on the neck. In eleven cases careful palpation of the neck, with a parathyroid tumor in mind, did not reveal a growth in that region, but on exploration only two failed to show a parathyroid tumor; in these two cases it may be that the tumor was present but not discovered at the operation. The case under review is an example of this,—the tumor was situated outside the capsule of the thyroid gland and was only revealed by postmortem examination. The relationship of the thyroid gland to the parathyroid adenoma is shown in Figures 1 and 2.

The principal complaint of most patients suffering from this disease is pain in the limbs, followed by spontaneous fractures and muscular weakness. X-rays of the bones show a progressive and generalized absorption of calcium salts, associated with thinning of the cortex and the presence of cystic areas. The bones are easily penetrated by the rays so that photographs are generally poor in quality, more especially in the advanced stages of the disease. The blood shows a high concentration of serum calcium and a low concentration of plasma phosphorus. There is an abnormally large excretion of calcium in the urine and a negative calcium balance.

FIG. 1

Pathological specimen showing relationship of the parathyroid adenoma to the left lobe of the thyroid gland.

FIG. 2

Lateral view showing parathyroid tumor on section.

Owing to the hypercalcaemia there are frequently present renal calculi and metastatic calcification in various organs of the body. In the majority of cases, after the removal of a parathyroid adenoma, the levels of the calcium and the phosphorus in the blood and the excretion of the calcium in the urine are rapidly restored to normal, although sometimes there is a temporary hypocalcaemia with subnormal excretion of the calcium in the urine. Latent tetany after operation appears fairly frequently and manifest tetany occasionally occurs, the symptoms varying considerably in severity. These symptoms are at once relieved by injections of parathormone subcutaneously and calcium chlorid intravenously. The symptoms as a rule disappear very soon after operation, but the return of the bones to their normal structure must be a matter of months or years.

Most of the cases of this disease have been treated at one time or another with vitamin D with temporary improvement; this raises the serum calcium, but its action is probably quite independent of the parathyroids. The increase of calcium in the blood after the administration of vitamin D is due to a greater and more complete absorption of ingested calcium. The parathyroids, on the other hand, increase the serum calcium by liberating it from the bones. One might assume that vitamin D would assist the parathyroids in maintaining the serum-calcium level and should be a very useful drug during the period immediately succeeding the removal of a parathyroid tumor.

CONCLUSIONS

1. A case of generalized osteitis fibrosa cystica, due to a parathyroid adenoma, is described, occurring in a Chinaman. The parathyroid tumor was found neither by clinical examination nor at operation, but was revealed at postmortem examination.

2. It is advisable to recommend surgical exploration of the parathyroid glands in cases of generalized skeletal decalcification if associated with hypercalcaemia.

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HERNIA OF THE KNEE JOINT (BAKER'S CYST)

BY EDWARD K. CRAVENER, M.D., SCHENECTADY, NEW YORK

Hernia of the capsule of the knee joint is an old subject, but an exhaustive search of the literature reveals very few articles bearing directly on it. It was first described in English by Mr. W. Morrant Baker in the Report of St. Bartholomew's Hospital in 1877[1]. Later, in 1885, the report was enlarged and two new knee cases were presented[2].

Mr. Baker states specifically or by implication that these herniae must:

1. Be connected with the joint.
2. Be lined with synovia.
3. Herniate through a normal or abnormal opening about the joint.

In the original paper eight cases are given. Because of the present improvement in diagnostic facilities some might be disputed. Two or three are beyond question.

The anatomy of the knee joint, while compact on the medial, anterior, and lateral sides, presents potential weaknesses in the posterior portion. The capsule is intimately associated with small bursae lying between and under the hamstring tendons where the reflections of the tendons of the semimembranosus and other muscles are not complete. These zones stand as potential hernial openings. Through these protrusion may occur when abnormal conditions increase the joint fluid.

The symptom complex becomes: the hernia first develops through a normal or abnormal opening; it is pinched by reason of the motion of the knee, and presumably more effusion develops,—a vicious circle.

The diagnosis of Baker's cyst is comparatively easy. A small mass can be felt in the popliteal space, either medial or lateral, but usually above the middle half; this fluctuates and is easily compressible. Drainage of the joint and replacement by air will show, in the anteroposterior view of the x-ray, a small cleared area; in the lateral view a bubble-like formation can be seen in the popliteal space.

The treatment of this disorder is: (1) palliative and (2) surgical.

If the condition seems to be entirely secondary to a local condition within the knee joint and causes only minor symptoms, a tight binder with a pressure pad directly over the tumor will help to minimize the disorder.

If the tumor has grown so large as to impinge on the popliteal nerves or to cause oedema of the leg by reason of obstruction of the venous flow, or if it interferes with the arterial supply, then the tumor can be approached from the rear, shelled out, amputated at the base, and the tissues approximated over the original canal.

CASE REPORT

A retired salesman, aged sixty-four, presented himself to the Clifton Springs Sanitarium and Clinic for treatment, complaining of dizziness and pain in the right knee joint. Physical examination showed marked arteriosclerosis and hypertension with blood pressure of 240/120. The liver was enlarged; the body showed signs of general degeneration. The right knee was freely movable save in complete flexion. There was a moderate amount of fluid within the joint. The capsule was not thickened. A small compressible tumor mass was felt on the outer side of the upper popliteal space. The knee was painful after exertion and the patient felt that this tumor was larger after he had walked beyond his usual custom. The joint was drained and injected with air. Tracings of the x-ray are shown herewith. On account of the patient's age and his manifest inability to stand major surgery, a tight elastic bandage was fitted and the patient walked with more comfort.

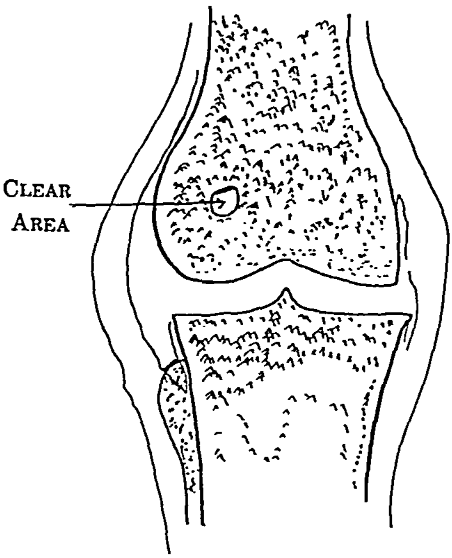

FIG. 1
Tracing of x-ray after air injection.

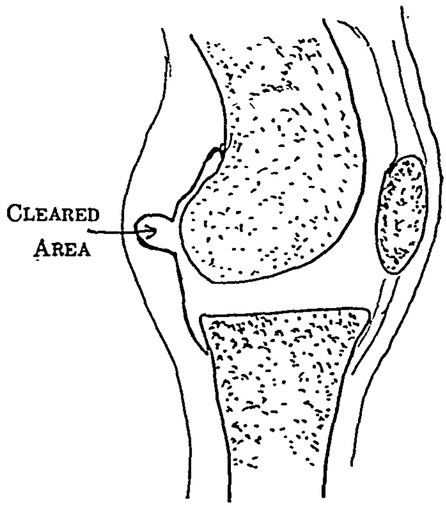

FIG. 2
Tracing of lateral view after air injection.

While this patient had a gross osteo-arthritis and probably derived most of his pain from this disorder, the potential hernia present in the posterior space had become real, due to the effusion into the joint.

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TWO CASES OF UNUSUAL CONGENITAL DEFORMITIES*

BY A. L. CRAIG, M.D., HONOLULU, HAWAII

From Shriners' Hospital for Crippled Children, Honolulu

Among the patients received during the past month in our out-patient clinic were two interesting cases of unusual congenital deformities.

CASE 1. M. A., aged one month, was the daughter of a father, aged thirty, of Norwegian-German ancestry and a mother, aged nineteen, of Hawaiian-Chinese parentage. There had been no other children. Wassermann test in the mother was negative.

Examination showed a well nourished child, apparently of good mentality, with a history of normal delivery. The abdomen and chest were normal. The shoulders

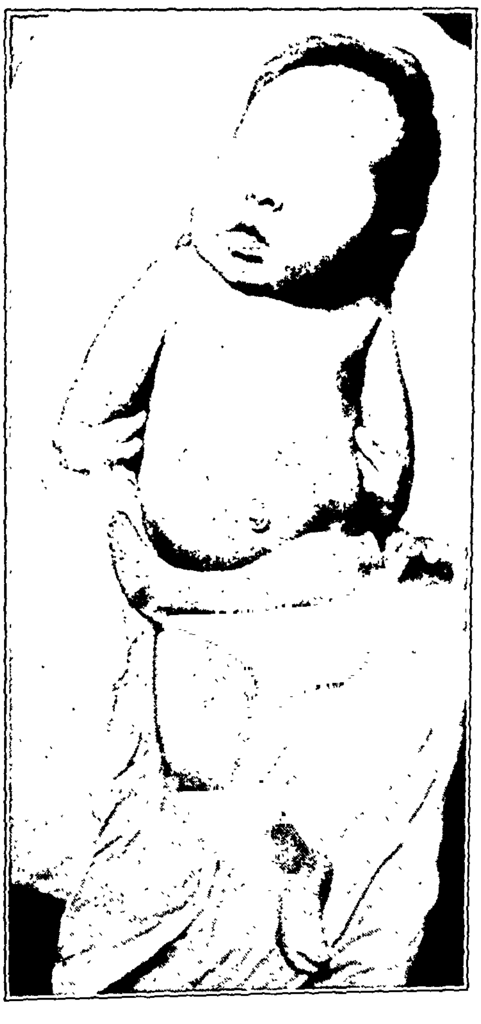

FIG. 1

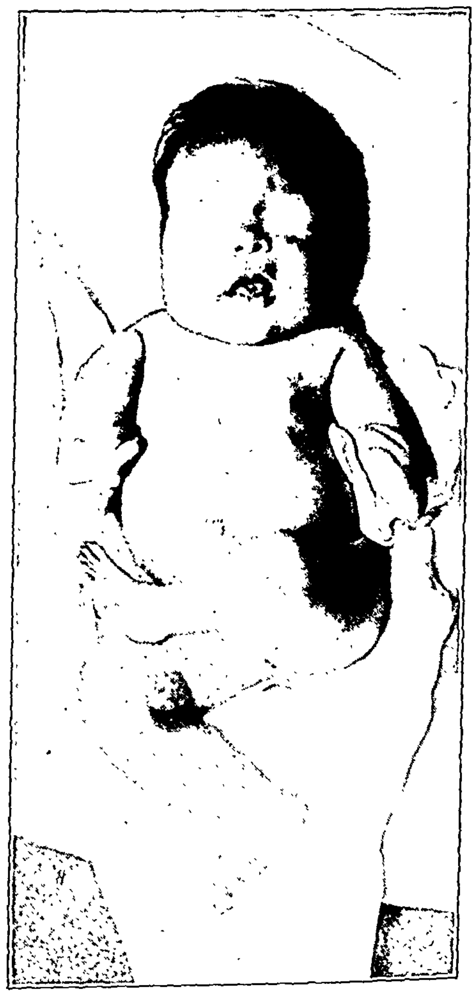

FIG. 2

*Received for publication, October 6, 1931.

FIG. 3

were normal, but no motion could be obtained in either elbow. The bilateral club hands showed two fingers on the right and three on the left (Figs. 1 and 2). There was a dislocation of the left hip with flexion deformity of the knee.

CASE 2. A. S., a boy, aged one month, was the fourth child of a Portuguese mother and a father of French-English parentage. The mother was thirty-five, the father thirty-six. Wassermann test in the mother was negative. The oldest of the three other children was a patient in a tuberculosis sanatorium.

The delivery of the child had been normal. Examination of the abdomen revealed a large inguinal hernia on the right side. There were bilateral club hands, with no motion at the elbow, and club feet in marked equinovarus (Fig. 3); dislocation of hip on the left side with flexion deformity of the knee.

A DEVICE FOR THE SIMULTANEOUS TRACTION AND COMPLETE IMMOBILIZATION OF THE CERVICAL SPINE

BY J. DEWEY BISGARD, M.D., CHICAGO, ILLINOIS

From the University of Chicago, Department of Surgery, Division of Orthopaedics

The importance of maintaining absolute immobilization with the application of traction to the cervical spine in the treatment of certain fractures and disease processes of the component vertebrae is well recognized. To immobilize effectively this portion of the spine the fixation must include its articulations with the occiput and thoracic cage. This is not accomplished by the procedures commonly used,—such as the Hanflig appliance, traction halters, and the Thomas and turnbuckle collars. For this reason, the device described below and illustrated in Figure 1 was evolved.

With traction applied to the head by means of a sling or halter in suspension, or on a horizontal frame, a plaster collar-jacket is molded snugly about the occiput and chin above and the shoulders and upper thorax below. Two pieces of canvas tape, with buckles attached, are incorporated in the plaster and their free ends are subsequently secured to the head of the bed, which is elevated, and traction secured by virtue of the patient's own body weight.

To permit the jacket portion of the cast to slide upward readily with traction, the plaster below the axillae is cut out widely. Especial attention is exercised to provide adequate felt padding and to cut windows for the relief of pressure over the ears if necessary.

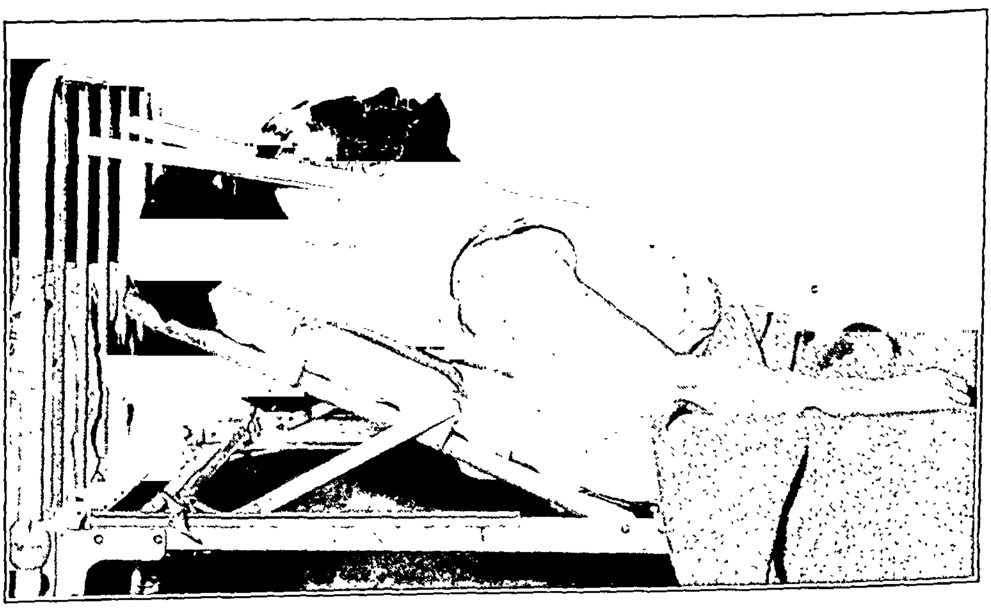

Fig. 1

With a carefully fitted jacket, the patient is surprisingly comfortable. This fact and the advantage of absolute immobilization, combined with the simplicity of its principles of traction, merit its consideration in the treatment of this group of cases. Its functional efficiency is further enhanced by the low cost of construction and the ease of application.

A SUPPORT FOR TRACTION AND COUNTERTRACTION

BY LESLIE V. RUSH, B.SC., M.D., AND H. LOWRY RUSH, B.SC., M.D.,
MERIDIAN, MISSISSIPPI

In the July 1931 issue of *The Journal of Bone and Joint Surgery* (XIII, 609) was published an article by Dr. H. Earle Conwell of Fairfield, Alabama, on "A Thigh-Knee Support for Countertraction". The device herein described is similar in principle to that of Dr. Conwell's and for that reason it is presented as a modification of Conwell's thigh-knee support.

(1) This apparatus serves the same purpose as the Conwell support for countertraction on the knee and thigh when traction is made on the leg and foot (Fig. 2).

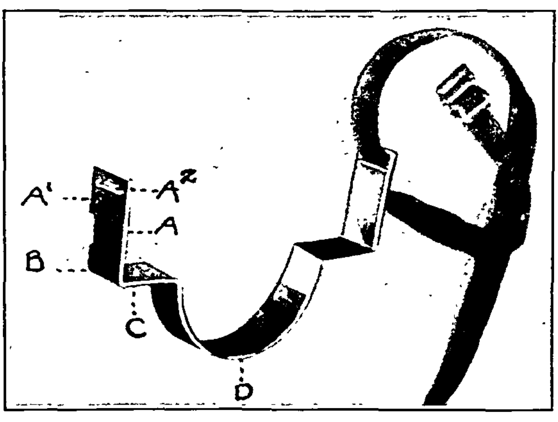

FIG. 1

The traction and countertraction support. It is made of a piece of band iron fifteen inches long, one and one-half inches wide, and one-eighth of an inch thick. *A* is three inches in length and is turned back one inch upon itself at the extremity (*A*¹). A slot is cut through each extremity at *A*², one and one-fourth inches long and one-fourth inch wide, for the passage of an inch-wide, web book strap. The band iron is bent to a right angle at *B*. *C* is two inches long. *D* is five inches long and bent into an arc to fit the contour of the leg.

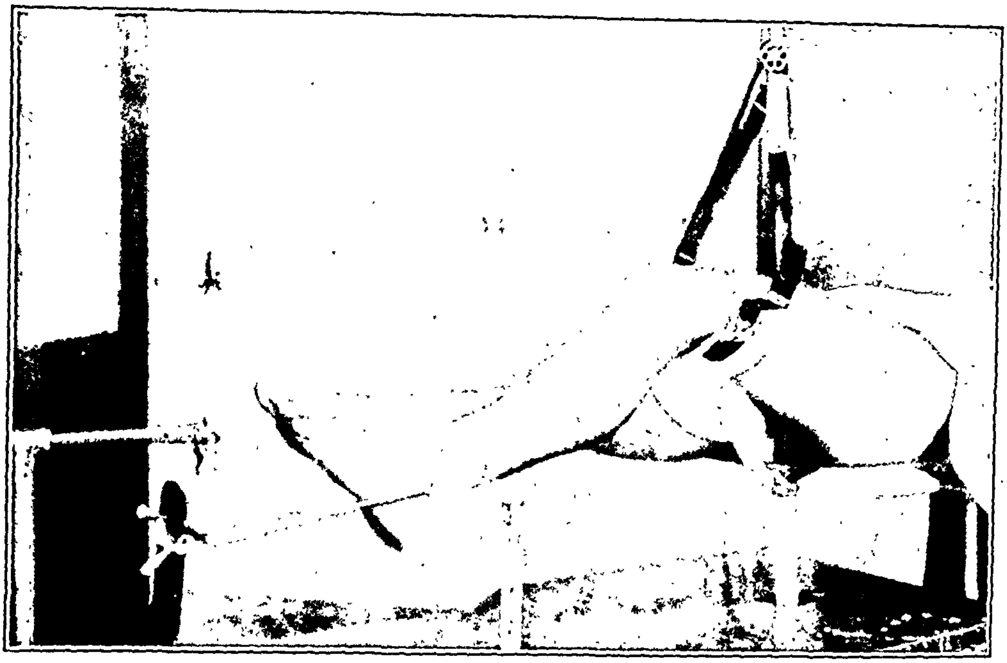

FIG. 2

Shows the apparatus applied on the Albee table for countertraction to the knee and thigh. Web book straps have been passed through the slots of the support and fastened over the horizontal bar on the upright. The support is raised or lowered by adjusting the straps. The leg is protected from the pressure of the iron band by a large felt pad. The cast is applied over the support. After the plaster has set the support is removed, the felt pad left in place, and the resulting window covered with several turns of plaster bandage.

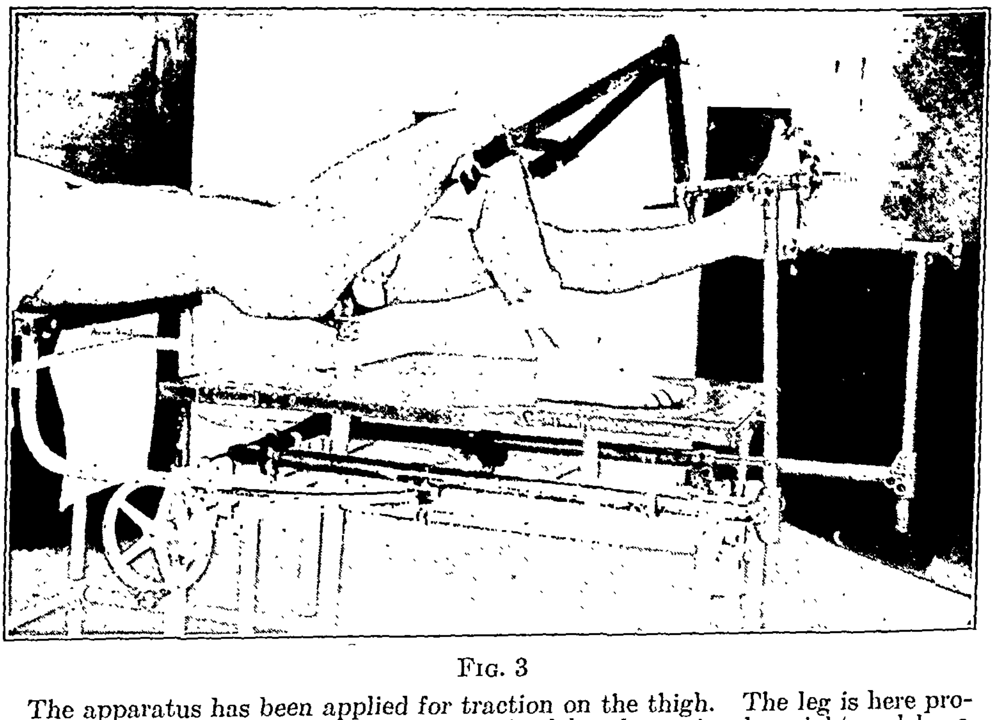

FIG. 3

The apparatus has been applied for traction on the thigh. The leg is here protected with felt. Countertraction is obtained by the perineal upright and by a gauze bandage passed from the sacral support to the lower third of the leg. The plaster cast is applied in the usual manner, the support being removed and that portion of the cast covered with plaster bandage as described under Fig. 2.

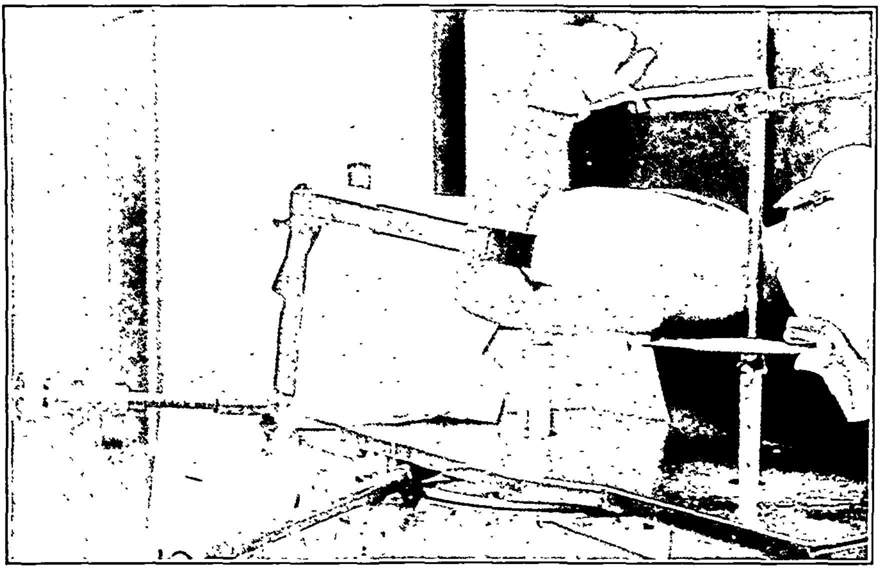

FIG. 4

Shows the apparatus being used for traction on the humerus. The patient has been placed on the body support, the head of the patient being at the foot of the table. The leg traction pieces have been brought out to the extreme lateral position. The forearm is protected with felt. A single web strap has been threaded through the slots and fastened over the foot piece. The wrist is tied to the upright with gauze bandage, so that the elbow remains flexed at an angle of ninety degrees. One assistant exerts countertraction on the sound limb, while a second assistant makes direct traction on the fractured side. The surgeon guides the fragments into position. A shoulder spica is applied. After the plaster has set, the traction piece is removed, leaving the felt in place, and the window is covered with plaster in the manner described above.

(2) It is simpler of construction and of application, and is easily adjusted to any desired height or position.

(3) It is useful for traction on the knee and leg when traction is to be made on the thigh with the hip and knee flexed (Fig. 3).

(4) It is useful for traction on the elbow and forearm when traction is to be made on the upper arm (Fig. 4).

A NEW APPARATUS FOR THE LENGTHENING OF LEGS

BY FRANK D. DICKSON, M.D., AND REX L. DIVELEY, M.D., KANSAS CITY, MISSOURI

The following described apparatus may be useful to those who are interested in leg lengthening.

This apparatus, which we feel is an improvement over that first described by Abbott, replaces the pin traction by the Kirschner wire device. The apparatus is really a combination of the Abbott device and the Kirschner wire apparatus. It is a distinct improvement over the pin method of traction as the wire is much more easily and more accurately inserted and there is less damage done to the bone and soft parts at the points of insertion.

The apparatus consists of a frame, the proximal end of which is made up of a horse-shoe piece (*B*) which holds the two stationary Kirschner wires (C_1 and C_2). Upon the two side bars (D_1 and D_2) slides the second horse-shoe piece (*E*) which holds the second two Kirschner wires (F_1 and F_2) in place. Continuous traction is made on the distal fragments of the tibia by the nut *G* and the spring *H*, this traction being transmitted to the tibia through the horse-shoe piece *E* and wires F_1 and F_2. This traction can be varied by the tension of the nut and spring on the side bars. The variable foot piece (*J*) holds the foot in the desired position.

The operation is performed in the usual manner, an oblique or Z-shaped osteotomy being performed on the fibula. This is followed by a Z-shaped osteotomy of the tibia. The incisions are then closed by layers without

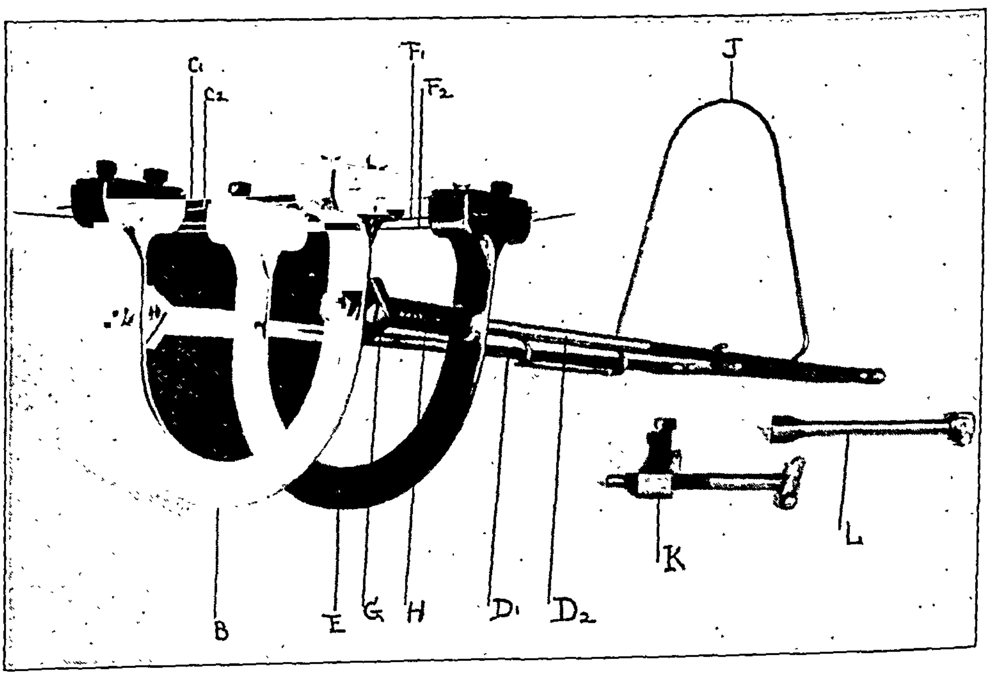

FIG. 1
Showing details of apparatus.

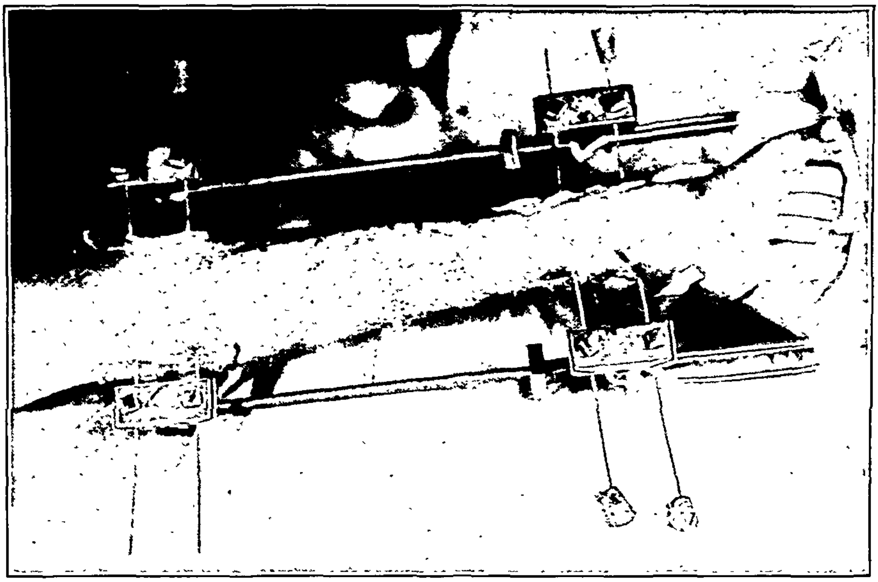

Fig. 2
Anterior posterior view of apparatus after leg has been lengthened.

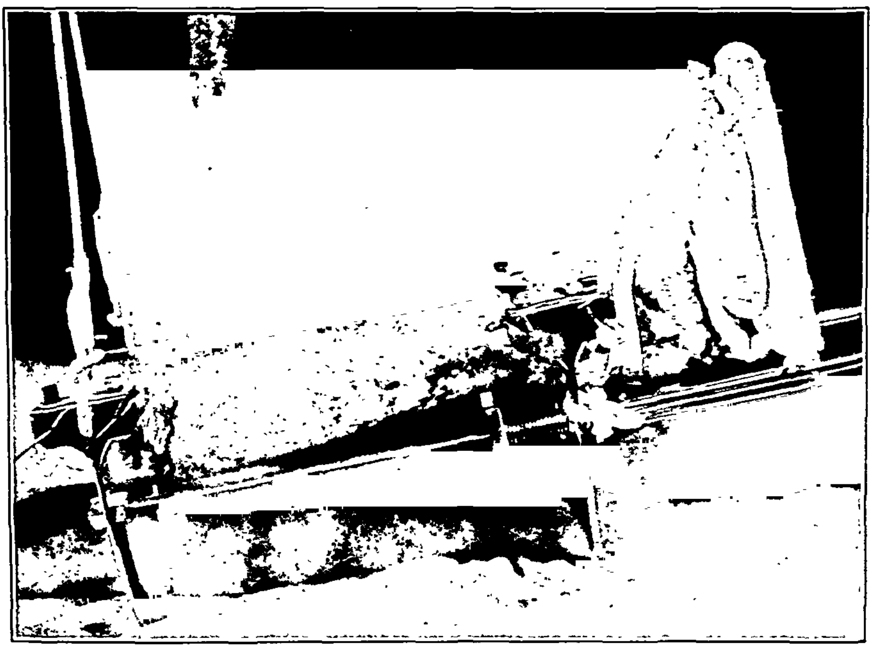

Fig. 3
Lateral view of apparatus after leg has been lengthened.

drainage and a tenotomy on the Achilles tendon is performed if necessary. The Kirschner wires are then inserted, two in the upper fragment of the tibia and two in the lower fragment, just below and above the limitations of the Z-shaped osteotomy. It is very important that these be placed in the same vertical plane and the spacing of the wires can be made accurately by using the base piece of turnbuckle *K*. After the four wires are inserted, the traction apparatus is fitted into place, the four wires being inserted into the grooves of the two horse-shoe pieces. The wires are then made taut with turnbuckle *K* in the usual manner and the wires tightened in place with wrench *L*.

RIGID SIDE BARS IN TIBIA LENGTHENING

BY KENNETH T. YOUNG, M.D., BROOKLYN, N. Y.

This simple adjunct is used after the desired amount of lengthening has been obtained by the method of tibia lengthening described by Abbott.

In each case the exact distance between the four pins is measured on both the inside and outside of the leg. It is necessary to measure each side separately, as there will be a slight difference between the two sides. Taking two pieces of ship steel one inch wide by three-sixteenths of an inch and long enough to extend two inches above the top and bottom pin, four holes are drilled in each to correspond to the positions of the four pins and of the same diameter as the pins. By means of a hack saw, each hole is slotted to the same edge of the steel bar.

With the entire Abbott apparatus in situation, a plaster cast is applied from the base of the toes to the mid-thigh with only the slightest amount of padding possible. The steel bars are then dropped over the four pins and the corresponding sides of the leg, so that each slot fits a pin firmly. The bars are then pushed firmly against the plaster cast. The side bars of the Abbott apparatus with their extension threads are removed, and the plaster cast finished, with the pins *in situ* and securely held in place because they are firmly locked by the rigid side bars which are incorporated in the plaster cast. Anterior and posterior windows may be cut over the tongue and groove of the tibia, so that the development of callus may be followed by a series of roentgenograms.

FIG. 1

Case I. X-ray taken forty-seven days after operation. One and five-eighths inches lengthening (the desired amount). No angulation.

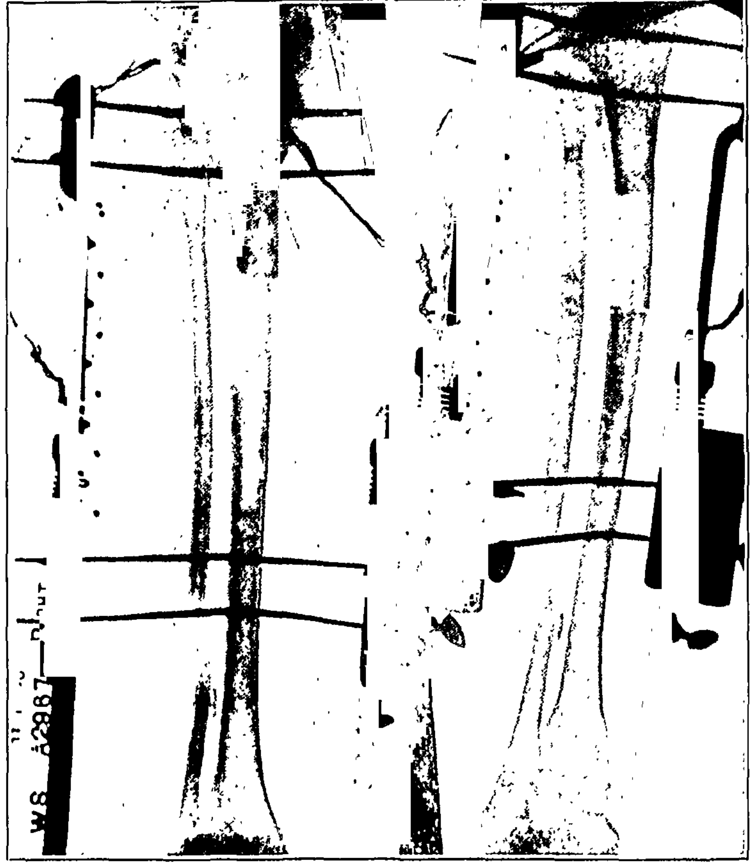

FIG. 2

X-ray taken ten days after Fig. 1. Overlengthening due entirely to action of the springs, as the traction devise had not been turned since previous film. Note the "tongue" has been pulled out of "groove".

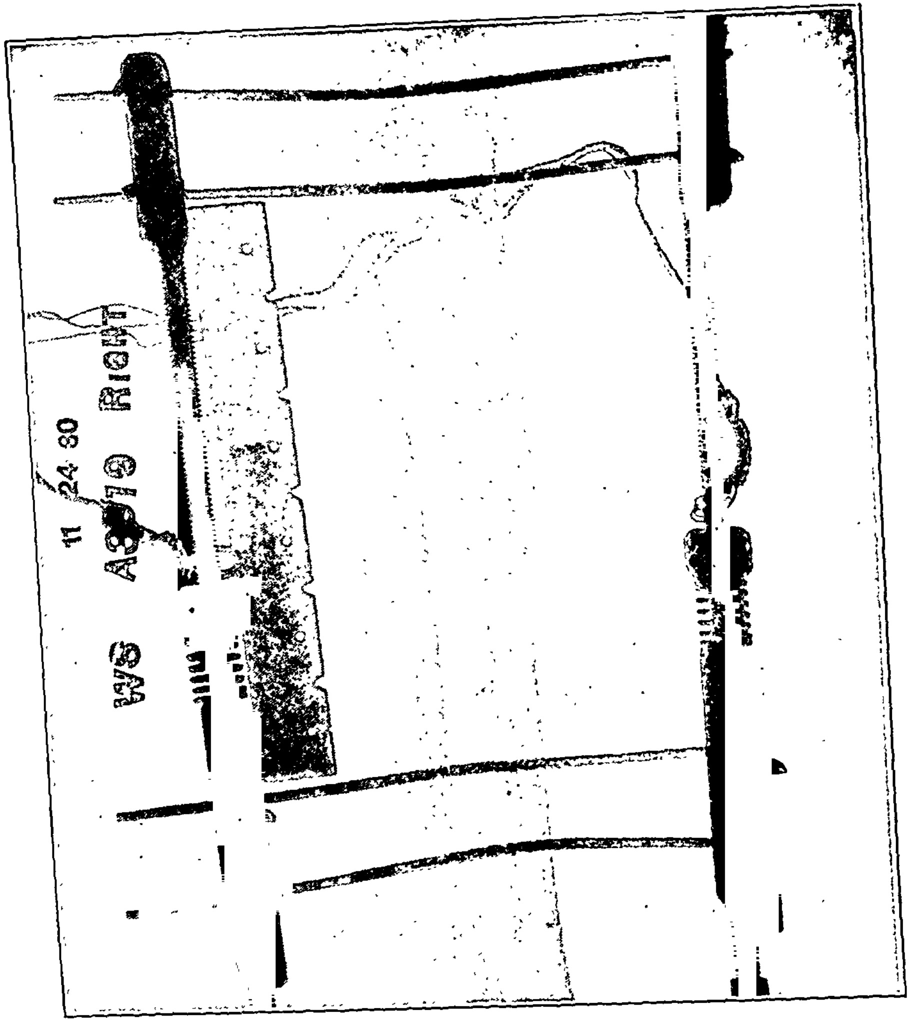

Fig. 3

X-ray taken three weeks after Fig. 2. Springs have been relaxed; measurement again shows one and five-eighths inches lengthening. "Tongue" is now in contact with "groove" but for the first time there is

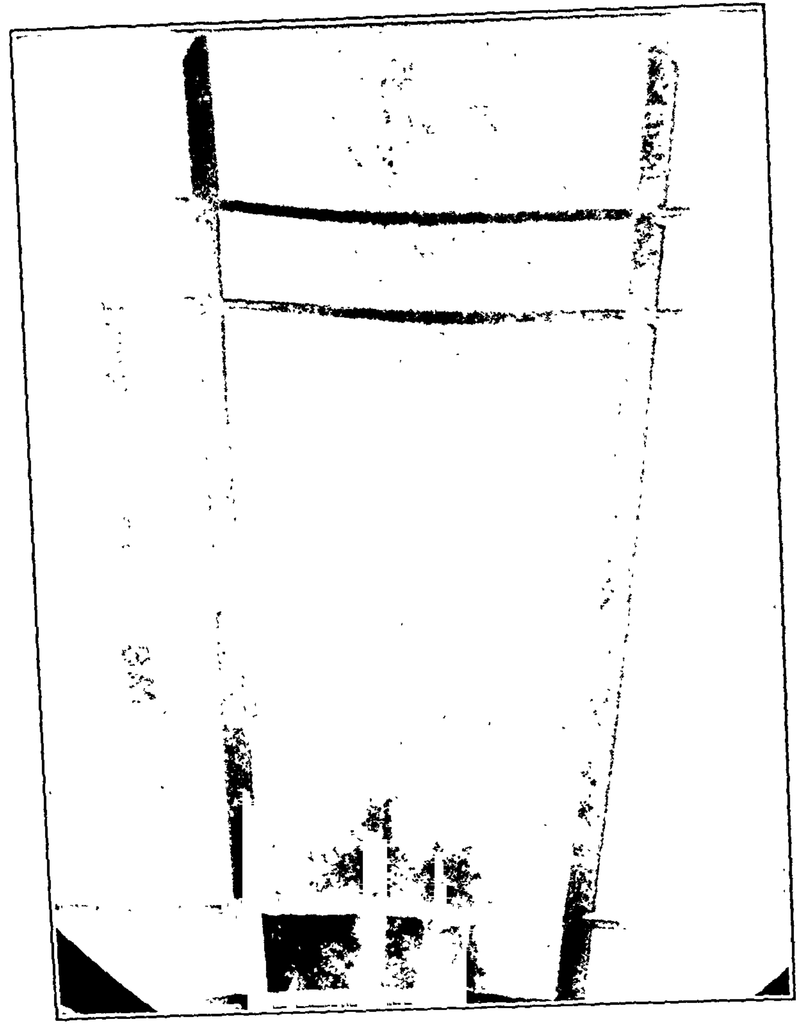

Fig. 4

X-ray taken after application of cast. Rigid side bars in place locking the four pins. "Tongue" and "groove" in contact and the callus about tongue showing clearly through the anterior and posterior windows in the cast.

SUMMARY

1. This adjunct is simple and inexpensive.
2. It constantly maintains the desired lengthening.
3. It saves the patient or the hospital the cost of four to six weeks of hospitalization.
4. It enables the patient to walk with, or without, crutches much sooner, for he cannot walk with the Abbott apparatus in place.
5. An active Orthopaedic Department needs fewer Abbott apparatus to take care of a definite number of cases in a given period of time as extra pins are all that are necessary.

REFERENCES

Abbott, L. C.: The Operative Lengthening of the Tibia and Fibula. J. Bone and Joint Surg., IX, 128, Jan. 1927.

Abbott, L. C., Crego, C. H., and Adams, A. O.: The Operative Lengthening of the Lower Extremity. Internat. J. Orthodontia, XV, 110, Feb. 1929.

News Notes

Dr. Z. B. Adams has moved his office to 472 Commonwealth Avenue, Boston, Massachusetts.

Dr. Fremont A. Chandler has moved his office to 180 North Michigan Avenue, Chicago, Illinois.

Dr. Arthur Steindler, President-Elect of the American Orthopaedic Association, has recently been elected a Corresponding Member of the Belgium Orthopaedic Society.

The second Sir Robert Jones Lecture at the Hospital for Joint Diseases, New York City, was presented on October 13, 1931, by Dr. W. Edward Gallie, Professor of Surgery at the University of Toronto and President of the American Orthopaedic Association. His subject was "Further Advances in the Use of Living Sutures".

A lecture on "Sciatica and Backache from a Neurological Standpoint" was delivered at the Hospital for Joint Diseases, New York City, on December 16, by Dr. Walter E. Dandy of Johns Hopkins University.

It is with great regret that we announce the death of San.-Rat Dr. A. Schanz of Dresden on November 17, 1931. Prof. Schanz has held a prominent position among the orthopaedic surgeons of Germany, and his name has always stood in the advance guard in progress. He has added much to the development of his special department of surgery.

We regret to announce the death of Prof. Stanislav Tobiášek at Prague, on November 27, 1931, at the age of fifty-seven. Dr. Tobiášek was Professor of Orthopaedic Surgery at Caroline University and head of the Orthopaedic Clinic of the University, and was President of the Czecho-Slovakian Orthopaedic Society for the current year. In 1929, after many years of effort, he succeeded in establishing the University Orthopaedic Clinic at Prague. His death came at the full height of his energies and in the midst of a successful scientific and clinical work.

On the twenty-fourth of November, Prof. Henry Turner of Leningrad celebrated the fiftieth anniversary of the beginning of his active practice. Prof. Turner is a pioneer in his chosen specialty in Russia and is regarded as the "god-father" of Russian orthopaedic surgery, and is a Corresponding Member of the American Orthopaedic Association. He has given many valuable contributions to the literature of orthopaedic surgery in the Russian, German, and English languages, and has always held a prominent position among the medical profession in his country. His friends are congratulating him and are expressing their appreciation of his successful career.

The Clinical Orthopedic Society met at the University Hospitals, Iowa City, Iowa, on October 30. Interesting case demonstrations were given by Dr. Arthur Steindler, Dr. J. E. Milgram, Dr. J. Kulowski, and Dr. T. H. Vinke.

The following orthopaedic surgeons have established an informal group called **The Orthopaedic Association of Michigan:** Dr. C. E. Badgley, Dr. W. E. Blodgett, Dr. F. E. Curtis, Dr. R. V. Funston, Dr. A. G. Goetz, Dr. F. C. Kidner, Dr. A. D LaFerté, Dr. C. W. Peabody, Dr. F. H. Purcell, Dr. D. M. Stiefel of Detroit, Dr. V. L. Hart, University of Michigan, Ann Arbor, and Dr. J. T. Hodgen of Grand Rapids. This Association has made provision for Associate Members who must have had some training in orthopaedic surgery, but not necessarily devoting their full time to this specialty. Their function is to cooperate in the after-care of the State's cripples, but they are not yet allowed to carry out any operative procedures.

The principal object of the Association is to cooperate with the State Commission for Crippled Children in the care of indigent cripples from all parts of the State. The law gives the Commission power to hold clinics in the various counties in cooperation with local groups, such as the Rotarians and the State Crippled Children Society. The clinics are conducted by one of the State's recognized orthopaedic surgeons. As far as possible, the clinics are taken care of by the surgeons in rotation. The State law allows the local probate judges to send children who are examined at these clinics to anyone of the recognized hospitals for treatment. Recognition of the hospital depends on the equipment judged sufficient by the Commission. It is also necessary that they recognize that an orthopaedic surgeon should be a regular member of the staff.

Dr. Arthur Steindler, of Iowa City, was one of the lecturers at the Annual Fall Clinical Conference of the **Oklahoma City Clinical Society** held November 2 to 5. His subjects were: "Reconstruction of the Upper Extremity" and "Abscess Formation in Vertebral Disease; A Study of Differential Diagnosis".

The Extension Division of the **University of Oklahoma** furnishes annually a post-graduate medical program in which an orthopaedic post-graduate course is carried out on a circuit plan throughout the State. This plan brings to the practising physician authoritative information on orthopaedic subjects. The program presented this year in November and December included the following lecturers: Dr. C. B. Francisco, Kansas City, Mo.; Dr. F. J. Gaenslen, Milwaukee, Wis.; Dr. W. B. Carrell, Dallas, Tex.; Dr. J. S. Speed, Memphis, Tenn.; Dr. A. E. Bence, Wichita, Kan.; Dr. H. Winnett Orr, Lincoln, Neb.; and Dr. Frank Dickson, Kansas City, Mo.

A meeting of the **North Pacific Orthopaedic Society** was held on November 7 at the Vancouver Hotel, Vancouver, B. C. An interesting program was presented by the following:

Dr. Richard B. Dillehunt — Demonstration of unusual fractures and dislocations.
Dr. Richard F. Berg — Pneumo-arthrolysis.
Dr. Charles R. McClure — Injuries of the Carpus.
Dr. W. H. Goering — Osteochondroma of the Acetabulum.
Dr. Roger Anderson — A New Method of Treatment of Lower Extremity Fractures.
Dr. William E. Grieve — Treatment of Fractures of the Clavicle.
Dr. Harry Blair — Diseases of the Intervertebral Cartilages.
Hernia of the Nucleus Pulposus.
Dr. Alfred O. Adams — Application of Thiersch's Grafts
Dr. H. J. Wyckoff — Os Calcis Fractures.
Dr. R. L. Jeffery — The Diagnosis of Arthritis.
Dr. John F. LeCocq — Klippel-Feil Syndrome.
An Unusual Congenital Deformity of the Spine.
Dr. Otis Akin — The Internal Fixation of Joint Fractures.

The following officers were elected for 1932:

President —	Dr. A. O. Adams, Spokane
Vice-president —	Dr. Richard Dillehunt, Portland
Secretary-treasurer —	Dr. William E. Grieve, Spokane

The Semi-annual Joint Meeting of the **San Francisco and Los Angeles Orthopaedic Clubs** was held in Los Angeles on November 7, under the leadership of Dr. H. D. Barnard, President of the Los Angeles Orthopaedic Society. The morning was devoted to interesting clinical demonstrations at the Orthopaedic Hospital by Dr. R. L.Carroll, Dr. Edwin F. Patton, Dr. Charles S. Young, Dr. Clifford A. Wright, Dr. Harold E. Crowe, Dr. Lowell S. Goin, Dr. A. Brockway, Dr. E. N. Reed, Dr. Howard Updegraff, and Dr. C. L. Lowman, and demonstrations in the underwater gymnasium by Miss Sue Roen. In the evening, following a dinner at the University Club, addresses were given by Dr. Morton R. Gibbons on "Industrial Accident Fees", Dr. Giles S. Porter on "California State Crippled Children's Act", and Dr. Junius B. Harris on "Medical Legislation and Economics".

At the Executive Committee Meeting of the **British Orthopaedic Association** held on November 30, the following were elected Full Members:

A. O. Parker, 80, Cathedral Road, Cardiff.
C. Gordon Irwin, 9, Sydenham Terrace, Newcastle.
Andrew Fowler, 9, Rubislaw Terrace, Aberdeen.
E. D. Telford, 169, Wilmslow Road, Withington, Manchester.
Pieter De Villiers Moll, 85, St. George Street, Capetown, South Africa.

The following were elected Associate Members:

Ralph Brooke, Warren Lodge, Western Place, Worthing, Sussex.
J. C. Drummond, Club of Western India, Poona, India.
John Taylor, 3, Somerville Place, Dundee.
S. G. Davidson, 53, Fountain Hall Road, Aberdeen.
H. J. Burrows, 6, Holly Lodge Gardens, London, N. 6.
N. L. Capener, Princess Elizabeth Hospital, Buckerell Bore, Exeter.

C. Thurston Holland, 43, Rodney Street, Liverpool, was elected an Honorary Member.

The Twenty-sixth Congress of the **Deutsche Orthopädische Gesellschaft** took place in Berlin on September 14, 15, and 16 under the presidency of Prof. Wollenberg. For the scientific portion of the Congress three main subjects were considered, all of which elicited a full and fruitful discussion. On Sunday, September 13, the President, according to custom, entertained the officers and invited guests at a luncheon.

On the first day, papers on the question of heredity were given by Dr. v. Verschuer of Berlin and Prof. Valentin of Hannover, — the former speaking on heredity and orthopaedic surgery, and the latter on constitution and heredity, emphasizing the importance of constitution as compared with heredity. A large number of members took part in the discussion and the emphasis was placed on the importance of the influence of heredity, dealing in particular with the special conditions met with in orthopaedic surgery.

The second forenoon was devoted to the consideration of spastic paralysis,— Dr. Hoffmann of Freiburg speaking on muscular tonus, and Dr. Stoffel of Mannheim on his particular field,— the resection of motor nerves. Dr. Stoffel made an exhaustive report of the work on this subject, including the method of selection and examination of cases for operation, the technique of operation, and the end results. There were also reports on more than 300 cases from the Berlin Orthopaedic Clinic. Following the afternoon session, the members and guests visited the Oscar Helene-Heim, founded by Prof. Biesalski and now in charge of Dr. Mommsen.

On the third day, the Congress considered the problem of operation on pronated flat-foot in children and young adults. The discussion was opened by Dr. Schrader of the Heidelberg Orthopaedic Clinic, who had collected opinions from a large number of orthopaedic surgeons and from the members of the Association. The very active discussion was directed mainly toward the consideration of the flexible foot and the stiff,

contracted foot, and it developed a wide diversity of opinion. A majority of the members present took part in this discussion. For the contracted, pronated flat-foot many diverse opinions in regard to treatment were offered, indicating that no one method of treatment is generally accepted, or is entirely satisfactory. Many were of the opinion that operations should not be performed except on sufficient indication of a definite impairment of function.

The remainder of the session was devoted to the presentation of papers on general subjects by the members of the Association, among which papers was an exceptional work by Dr. Böhm on the origin of the congenital dislocation of the hip.

Prof. Stoffel was elected President for the ensuing year and the next Congress will be held in Mannheim.

The Seventh Annual Congress of the Czecho-Slovakian Orthopaedic Society was held in Brno on September 27 and 28, with Prof. Dr. Bedřich Frejka as President. The first day was given to the inspection of the Institution of the National Society for the Care of Crippled Children at Brno, and of the hospitals and the clinics, with a demonstration of cases under treatment by the members of the staffs of the hospitals. The usual banquet was held in the evening. Dr. E. G. Brackett of Boston was the official delegate of the American Orthopaedic Association.

The second day was devoted to the presentation of papers. The principal subject for discussion was "Mineral Metabolism and its Relation to the Skeleton". Prof. Frejka, the President, presented the opinion that osteomalacia in adults is identical with rickets in children. His evidence for diagnosis in this condition is: the lowering of the level of calcium in the blood, which test, however, is not always positive; the elimination of calcium from the body, as seen by inspection of the teeth and x-ray study of the skeleton; proof that mineral metabolism is influenced by unsuitable food and by the lack of sunlight and fresh air; and proof of the therapeutic influence of alkaline foods, cod-liver oil and viosterol, and the effects of the mercury vapor lamp.

Prof. Bečka, of Brno, discussed the biological chemistry of calcium and phosphorus. The conditions for the physiological utilization of calcium in the body are: optimal reaction (pH 7.3 to 7.6), parathormon, vitamins, light, and the presence of active magnesium. The author assumes that phosphorus has similar conditions, as it is usually bound with calcium. Disturbances in the exchange of either element are of two kinds,— physiological and pathological. Disturbances caused by "calcium hunger" are tetany and osteoporosis; imperfect function in the exchange of calcium is shown in osteomalacia; the lack of phosphorus results in asthenia of the muscles; and rickets is evidence of a disturbance in the exchange of phosphorus. Therapeutically, the absorption of calcium salts is aided by adding magnesium to the food, especially in the form of hydroxid.

Prof. Laufberger, of Brno, gave the results of an exhaustive survey of mineral metabolism, which he demonstrated by tables and diagrams dealing with the topography of minerals, and with the movements in the digestive apparatus, and the mineral exchange as controlled by the nerves, hormones, vitamins, and ions.

Prof. Petřivalský, of Brno, spoke on the therapy of bone defects and stated it is first necessary to resort to operative treatment, applying iodin to the walls, and using some material to fill the spaces,— such as the Bečka paste which has an acid reaction, and helps to solidify its environment and to aid in dissociating the calcium and phosphorus in the bone. Second, in the constructive stage, crystals of the secondary and tertiary carbonates form during the time of slight alkaline reaction, and beam-work is gradually formed, which is aided by proper diet,— consisting chiefly of vegetables and a proper quantity of calcium chlorid.

Other speakers on the subject were Prof. Stoklasa, Prague; Prof. Zimák, Brno; Prof. Novák, Brno; Dr. Zelinka, Šumperk; Dr. Minář, Ljubliana; Dr. Uher, Brno; Dr. Přibyl; Dr. Felsenfeld. Dr. Rapant, of Brno, spoke particularly on the relation of calcium in conditions of acholic cachexia. Prof. Stoklasa spoke especially on radio-activity as an important biological factor with respect to old age. Prof. Bažant, of Brno, spoke

on the effect of mineral metabolism on the teeth and Prof. Novák gave a survey of the normal biological and biochemical processes during the healing of fractures. Dr. Zelinka spoke on the effect of the Hermannsdorfer diet in the treatment of bone tuberculosis and Dr. Minář discussed the importance of the use of inorganic salts in convulsions following orthopaedic operations.

The remainder of the session was occupied by the presentation of papers by Dr. Schulz, Dr. Mikula, Bratislava; Dr. Vidlička, Levice; Prof. Podlaha, Brno; Dr. Skřivánek, Brno; Dr. Jaroš, Prague; Dr. Polívka, Prague; Dr. Bedrna-Popek, Brno; Prof. Frejka, Brno.

Prof. Stanislav Tobiášek of Prague was elected President of the Society for the ensuing year.

The Annual General Meeting of the **British Orthopaedic Association** was held at Newcastle-on-Tyne on Friday and Saturday, October 30 and 31. The first morning was devoted to the reading of short papers, and in the afternoon cases were demonstrated at the Royal Victoria Infirmary.

Dr. Whateley Davidson, Newcastle, reported a case of osteochondritis ischiopubica in which there was limping and pain suggestive of early tuberculosis of the hip with tenderness and swelling over the ischiopubic ramus. X-rays showed a globular swollen appearance of the cartilaginous junction of the rami of the ischium and the pubis. The condition is rare and is thought to be traumatic in origin and analagous to osteochondritis of epiphyses. Symptoms subsided within a few months and the x-ray appearance became normal.

Mr. John Gilmour, Newcastle, reported the end results in a series of eighty-seven cases of tuberculosis of the hip. Conservative treatment in an abduction frame secured recovery of a limited range of movements in a large proportion of cases. A short fibrous ankylosis was a satisfactory end result, but recurring flexion-adduction deformity requiring repeated osteotomies was not infrequent. If the hip became unstable and dislocation or wandering acetabulum threatened, an extra-articular arthrodesis was advised.

In the discussion Mr. Naughton Dunn, Birmingham, stated that multiple osteotomies could be avoided if the child whose hip disease had become quiescent was left without apparatus for six months until maximum possible deformity had developed before the osteotomy was performed. Mr. McCrae Aitken, London, advocated non-weight-bearing, unloaded movement after the disease was quiescent, which encouraged recalcification of the femoral head and acetabulum and prevented flattening of the bearing surfaces. Mr. T. P. McMurray, Liverpool, strongly recommended conservative treatment, for the majority of adequately treated cases returned to work with a strong stable hip.

Mr. R. C. Elmslie, London, described seven cases of deposition of amorphous calcium in the supraspinatus tendon just above the great tuberosity. This should be differentiated from fracture of the tuberosity and from loose bodies in the joint. Very severe pain arose, and excision of the whole sac, including the adjacent part of the tendon, was advised. Symptoms were completely relieved and did not recur.

Mr. Ollerenshaw, Manchester, reported two similar cases. Mr. Watson Jones, Liverpool, said that the condition was exactly analagous to calcification of the semilunar cartilages, intervertebral discs, fibrosed lymph glands, and organizing blood clot, and was due to fibrosis. It occurred in other tendons, notably the tendo achillis after tenotomy. Occasionally the deposit could be aspirated subcutaneously with complete relief of symptoms.

Mr. Watson Jones demonstrated a simple portable apparatus by which anatomical reduction of overriding fractures of the shafts of the tibia and fibula could be secured, which allowed immediate fixation in plaster. Reduction was just as perfect as when an open operation was performed, and all the disadvantages of extension methods were avoided. The complete treatment of a case was illustrated by means of a cinematograph film.

Mr. S. A. S. Malkin, Nottingham, compared the relative merits of Albee's, Hey Groves', Gibson's and Hibbs' operations for fusing the spinous processes and laminae in tuberculosis of the spine. He was in favor of laying a double tibial graft on the laminae, one on either side of the bases of the spinous processes. Solid bony fusion could be demonstrated radiologically.

Mr. H. C. Edwards, London, opened a discussion on injuries of muscles and tendons and based his opening remarks on the paper for which he was awarded the Robert Jones Medal and Prize for 1931. He said that muscle strains should be treated by early exercise to avoid adhesions, and prevent wasting of the muscle as a whole. Massage was entirely useless. As a general rule ruptured muscles should be sutured in order to allow early exercise and movement. Late operations by fascial implantation where the retracted muscle belly had fully shortened were of no value. Pathological rupture of the long head of the biceps in chronic arthritis of the shoulder, "drummer's rupture" of the extensor pollicis longus, and spontaneous rupture of this tendon, following fractures of the lower end of the radius, were discussed. Other occupational muscle injuries were rupture of the tendo achillis in mountaineers, of the pectoralis major in boxers, of the external oblique in reapers, and the adductor longus in cavalrymen. Avulsion of the extensor tendon of the finger (mallet finger) was best treated by operation. Open wounds of the flexor tendons gave very poor results. Immediate operation in Hospital Casualty Department was strongly deprecated, not only because the operation was too difficult for any but a very experienced operator, but also because the risk of infection was much less after several days' interval. Bunnell's buried suture and immediate active movements with no immobilization were essential.

Mr. Rocyn Jones, London, had personally sustained a partial rupture of the calf muscles and had found raising the heel of the shoe to be of no value. Local strapping was beneficial. Mr. H. Platt, Manchester, said that the only reliable sign of complete rupture of the tendo achillis was an abnormal range of dorsiflexion at the ankle joint. Operative treatment was then necessary. Mallet finger should be treated conservatively by fixation for six weeks. Although the terminal joint required hyperextension, both of the other joints should be flexed. Mr. W. Trethowan, London, had observed the results of treatment by massage and exercises of a complete rupture of the tendo achillis in a professional dancer who had refused operation. The tendon united with half an inch of lengthening and, although the patient did subsequently dance, she was now much less efficient and had recently returned asking for operative treatment. Mr. Watson Jones said that myositis ossificans at the elbow and knee joints was purely traumatic and due to avulsion of a muscle insertion with periosteum. It was not an inevitable complication, and was curable by suturing the periosteum back to the bone. In cut finger tendons the suture of the profundus tendon alone was advised. This tendon provided ample power and, if the sublimis tendon was completely cut away, adhesion formation was minimized. Mr. Elmslie said that he had never seen a really satisfactory result when a flexor tendon of the finger had been cut below the distal palmar crease. Almost every speaker who had taken part in the discussion was in agreement and spoke in very strong terms of the danger of allowing Casualty Officers to suture cut tendons. The operation was never to be regarded as an emergency. Not only should several days elapse before it was undertaken, but the patient should be admitted to the wards, treated as a major case, and only operated upon by senior surgeons, preferably those accustomed to tendon surgery.

Current Literature

CLINICAL OBSERVATIONS ON THE SURGICAL PATHOLOGY OF BONE. By David M. Greig M.B., C.M., F.R.C.S. EDIN., F.R.S.E. Edinburgh and London, Oliver and Boyd 1931. 30 shillings.

The advantages of a varied hospital experience as surgeon to institutions where opportunity for the study of bone pathology has been abundant and access to the museum of the Royal College of Surgeons in Edinburgh where, for many years, the author has been conservator, are very apparent in the volume with the above title. The result has been the presentation of a refreshingly new conception of the changes that take place in bone as the result of injury and disease and a far more satisfying explanation of many of the clinical manifestations with which every surgeon having to deal with bone pathology has heretofore had offered to him. The old ideas of the methods of osseous growth have been obliged to give way in certain respects. No longer is the periosteum credited with the power to deposit bone as it used to be. The layer of cells in the periosteum formerly regarded as osteogenetic should properly be regarded as either fibrogenetic or osteogenetic and as such may be recognized at any period of life as a part of the phenomena of repair where bone is concerned, which is a wholly analagous process to that occurring in any connective tissue, which bone unquestionably is. In the present-day view the osteoblast is merely a fibroblast that has enlarged on account of its activity. These cells are subject to environmental influences and, to some extent at least, are under the control of hormones. The theory for a long time held that cartilage could be transformed into bone is untenable. Embryologically speaking, a mesenchyma cell may be differentiated into fibrous tissue, cartilage, or bone. Alteration in blood supply is a factor that plays a part in this process of differentiation and the influences that determine alterations in blood supply are derived from enzymes set free from certain cells rich in protein, a reflection of an orderly, and sometimes perhaps a disorderly, disturbance of the endocrine balance of the body. As a result of such biochemical changes a preosseous substance is laid down which is not hypothetical but demonstrable and long recognized as existing, but given no credit for playing any part in the process of bone building or repair. A second important property of the embryonic bone cell is halisteresis, the setting free of calcium. For all bone-building processes whether they are concerned with new bone formation, or pathological changes in disease, or the repair of osseous injuires, adequate blood supply and adequate calcium supply are essential. All cells, whatever their function or location, contain a substance called histamin, the liberation of which from the cell results in a physiological, local increase in the blood supply which induces hyperaemia and a transudation of blood serum. Pathological vasodilatation is produced in more profound injuries to tissue by a substance known as acetylcholin. When produced by the liberation of this substance vasodilatation is profound and prolonged. The general deduction he makes which constitutes the practical value of his observation and the observations of others is that: (1) if the circulation is maintained within certain limits bone remains normal; (2) if hyperaemia is produced bone undergoes rarefaction, decalcification, and osteoporosis; (3) if the blood supply is cut off bone undergoes necrosis. The bearing of these fundamental concepts of the behavior of bone under certain physiological and pathological conditions is then shown in such matters as the transplantation of bone, the production of foreign (osseous) bodies within joints, the osteoporosis following certain fractures (*e.g.*, Colles' fracture and intracapsular fractures at the hip joint), reflex joint atrophies, the alterations in skeletal architecture that are constantly taking place, infections in bone (in the periosteum, the marrow, and the cortex) the formation of sequestra and involucra, osteitis from septic arthritis, tuberculosis, syphilis (osteosclerosis), fibrositis ossificans progressiva, traumatic osteoma about joints, osteitis fibrosa, and the malignant tumors of bone,—*e.g.*, carcinoma (metastatic) and sarcoma.

One cannot read the latter portions of this volume, applying the principles defined in the first chapter, without feeling that a flood light has been thrown on the pathology of bone and that this pathology in no way differs essentially from pathology elsewhere, but has heretofore been looked upon as something apart. Certain aspects of the pathology of the chronic types of arthritis will be made more understandable from the application of the knowledge of the tissue reactions in osseous structures, brought about by distrubances in the vascular network in the neighborhood of articulations.

Diagnosis in Joint Disease. By Nathaniel Allison, M.D., F.A.C.S., and Ralph K. Ghormley, M.D. New York, William Wood and Company, 1931. $9.00.

In the preface the authors urge a greater accuracy of diagnosis based on the knowledge of tissue change as well as of the etiological factors, and, in so doing, endorse the efforts of the many earnest workers in this subject in the attempts to discover the actual causes of this baffling disease. Unusual opportunities have been at their disposal to study the different phases of this subject in order to arrive at a satisfactory solution of this problem,—the facilities offered in the clinic of a large hospital, with the coordinated efforts of the members of the various departments,—such as the orthopaedic surgeon, medical clinician, biologist, chemist, and reontgenologist. In this investigation they have studied the subject with reference to: (1) the etiological factors; (2) the joint tissues primarily invaded or infected; and (3) the character of these tissue changes.

The work is presented in eight chapters: Introduction to the Physiology and Chemistry of Joint Structures; The Classification of Arthritis; the arthritides of known origin,—including Tuberculous Arthritis, Traumatic Arthritis, Arthritis Associated with "Loose Body" Formation, Pyogenic Infection of Joints; and those of uncertain origin, which are considered in two chapters, using the terms of Nichols and Richardson,—proliferative arthritis and degenerative arthritis.

A discussion of the classification of arthritis is always interesting and the chapter in this book is no exception. The classification, which almost might be called grouping, clearly indicates the method used by these authors, and is based on etiological factors and the primary tissue changes. This plan has directed their methods of study in this subject. The difficulty in completing a satisfactory classification today is shown by the term used by the authors to designate the group of arthritides of "uncertain origin" under which is placed those cases of undetermined origin, characterized by their peculiar clinical course and the pathological appearances, and which still refuse to fall into line. These are considered as comprising the group in which the etiological factors cannot be determined, and which, until further knowledge is available, must elude the attempts in any system of grouping to place them in a definite position. This chapter will be found interesting, for in it are also considered the pathological changes in the various structures of the joints as well as their methods of study for this classification.

In works of this kind on the general subject of arthritis, tuberculosis is not always considered, but, in this book, a generous portion is given to this subject, which is in accordance with the method of using etiological factors as a basis in addition to the clinical course of the disease, and each portion of the subject is fully and very carefully described.

To this discussion of each form of arthritis are added numerous illustrative case reports. The practitioner who is particularly concerned with the treatment of his patients and with prognosis, as well as end results, will regret that, since the clinical history of the onset, etc., is given, the outcome of the cases which are quoted throughout the work is not added. The work, however, is mainly confined to the consideration of the etiological and pathological factors with reference to diagnosis, but the end results would have made an excellent balance to the pathological and clinical data to this much studied disease, the definite information in regard to which is still elusive. It is by this continued study, however, that this disease will finally be placed among those which are now better understood and which are better treated. Under the terms of Nichols and Richardson the proliferative (atrophic) and degenerative (hypertrophic) types are placed

in the classification of "uncertain origin"; these cases are fully and carefully described and the pathogenetic and pathological findings clearly presented.

The authors quote freely from well known writers in the clinical description and in the theory of origins of these forms of arthritis, and finally summarize their own observations on these two types of joint manifestations. The specialist as well as the practitioner should devote considerable time to the study of this book.

The authors have presented this study in an attractive, almost an elaborate form, with copious illustrations including particularly well selected and clearly defined roentgenograms and nine colored plates. It is evident that they have spared no expense in the presentation of this work, on which they evidently have put a great deal of their time and thought.

Atlas de Radiographie Osseuse Squelette Pathologique. I. Lésions Traumatiques. By G. Haret, A. Dariaux, and Jean Quénu. II. Lésions Non Traumatiques. By Étienne Sorrel and Mme. Y. Sorrel-Dejerine. Paris, Masson et Cie, 1931. 310 francs.

Four years ago these authors presented the "Atlas de Radiographie du Système Osseux Normal", giving the roentgenologic appearances of the normal skeleton and showing its development in different periods of growth from the new-born to the adult. This was intended to form a basis for comparison with the abnormal conditions, traumatic and pathological, which were to be considered in later volumes by the same authors. It has formed a most comprehensive presentation of this subject of normal anatomy, and has unusual illustrations of all parts of the skeleton with explanatory legends. This edition has been exhausted, but is now revised and republished. A second issue of this series has now appeared, and is of the same excellent and thorough presentation. It consists of two volumes: one dealing with the traumatic and one with the pathological (*lésions non traumatiques*); and, in the study of the material in these two volumes, the first book, on the normal bone, proves to be most interesting and important.

The first volume is devoted to the traumatic lesions. In the selection of the subjects for the illustrations, the authors have chosen types which have been recognized by the years of clinical and pathological observation, and have chosen those most frequently seen, as well as those which experience has proved to be most important. They have accompanied the photographs of fractures by diagrams, drawn personally by one of the authors, to characterize the type of lesion, with the object of presenting each with greater simplicity and clearness. All are shown as of the right side of the body, which is of advantage in the study of types rather than individual cases, and, as far as possible, the photographs are presented free from retouching of the negatives. In taking the x-rays of fractures, the authors insist on the necessity of views in different planes, because of the fact that many fractures are not visible in one plane alone, and illustrations are given demonstrating the truth of this statement.

In the volume on pathological lesions, as in the volume on traumatic lesions, the authors have chosen types to represent the various pathological conditions; they do not attempt to issue a complete atlas, but rather to give the more common and more important lesions, particularly to show the development of the progressive lesions,—as, for instance, the tuberculous. The authors have given tuberculosis a prominent place and generous space, which shows good judgment because of the importance of these lesions. They show not only the various types of these bone lesions, but also the progress in their development, as well as the end results of old cases of tuberculosis. The appearances of lesions in different stages of their development, with end results, are shown both .in children and adults. This volume also considers lesions in arthritis, the neoplasms, and the dystrophies.

The wise selection of cases presented in these two books, following the many years of general accumulated clinical experience, will give the reader practically all of the varieties of lesions which will come to his notice. The individual varieties of the type are of less importance provided the principle of the type is fully demonstrated.

Die Neuropathischen Knocken—und Gelenkaffektionen (The Neuropathic Bone and Joint Lesions). By Prof. Dr. August Blencke and Dr. Bernhard Blencke. Stuttgart, Ferdinand Enke, 1931. 46 marks.

The work on neuropathic arthropathy which was begun by Dr. August Blencke in 1904 has now been completed as the eighth volume of *Deutsche Orthopädie*. This monograph is the third of the series to appear in the last ten years. It is divided into a general section covering the pathology and treatment of neuropathic skeletal lesions; a section with the discussion and voluminous case reports arranged topographically; and a third part which considers the relation of the subject to trauma in a medicolegal sense.

That a three-hundred-and-four-page discussion of so limited a subject is detailed goes without saying. The bibliography alone comprises twenty-five pages of fine type. Each point that is brought up in the text is elaborated to such an extent, with quotations from the literature and illustrative cases, that one longs at times for a friendly subheading in the blackness of the pages.

The arthropathies and pathological fractures of tabes naturally comprise the bulk of the material. Cases of general paralysis, hemiplegia, syringomyelia, transverse myelitis, and injury and malformation of the spinal cord are among those in which typical or bizarre skeletal changes are reported. The details of conservative and radical treatment are so well illustrated that less text and a few legends would have spared the reader much time. Because of its imposing solidity, few will read the paragraphs consecutively, but as a reference work it will endure as a worthy addition to our valuable orthopaedic monographs.

Accidental Injuries: The Medico-Legal Aspects of Workmen's Compensation and Public Liability. By Henry H. Kessler. Philadelphia, Lea & Febiger, 1931. 718 pages, $10.00.

The field covered by this text is the narrow and highly specialized one concerned with the compensability of workmen's injuries. Because of the nature of the subject its appeal to physicians will not be wide, but to those concerned in the subject, it should prove an invaluable fund of information. Perhaps it would be better if practising physicians engaged in the treatment of injured workmen were more familiar with the laws which govern their compensation and the multitude of intricate problems which beset their administration. To such practitioners this book also will be of interest since it deals extensively with problems in which they have at least a secondary interest.

After a brief historical review, Kessler discusses the fundamentals underlying all compensation laws. The laws of the various states in the United States and those of many other countries are used for illustration. There is a chapter devoted to discussion of "Schedules for Specific Injuries". Then follows, in thirteen chapters, the detailed discussion of every type of injury and occupational disease. Kessler's experience as medical advisor to the Workmen's Compensation Board of New Jersey has given him an unusual fund of information and this forms the basis of his book. It is of interest to Canadians to note that he regards as unique the Scoliosis Committee of the Province of Ontario. He devotes considerable space to a detailed description of its function.

This book should prove invaluable to executives of Workmen's Compensation Boards. It is full of interest to all engaged in public health work. The general practitioner and industrial surgeon will find in it much information concerning a great piece of social legislation, with other angles of which he comes into daily contact.

Radiothérapie: Technique du Dosage en Profondeur. By Charles Guilbert in collaboration with Dr. Jean Quivy. Paris, N. Maloine, 1932. 437 pp., 60 francs.

The authors state in their general introduction to the volume that there is but one radiotherapy, whether it be superficial or deep, and that the physics and the radiophysiology of the two are the same. They state that the selectivity of the various rays is problematical, and the dominant question is in regard to the absorption of the rays by

the tissues; throughout the work they have in mind the practical final factor of the application of the dosage to the various tissues of the body and for the different pathological conditions.

The book is divided into four parts. The first part is given over to the description of the physics and the discussion of the x-ray, the machines for its use and the laws of absorption. The second part is devoted to the general consideration of radiotherapy, its action on the tissues and organs and on the blood, the dosage, the mechanism of the action, the pathological action of irradiation, and the consideration of the application of x-rays of various strengths to the various pathological conditions. The third part treats of the general methods of irradiation, dealing particularly with the development and regulation of dosage, and carefully explains the meaning and significance of the terms "superficial and deep irradiation", and gives directions for the use of both. The fourth part is devoted to the explanation of methods for the application of the radiotherapy to various organs and parts of the body and to the different pathological appearances for which the irradiation is used. These are extensively considered and in detail.

The book shows care in preparation and presentation of this material and gives evidence of large experience in this subject. It is of value to the reader who has need of familiarizing himself with the physics and with the therapy of the x-ray, as well as to the specialist. The book contains a most complete bibliography.

Surgical Pathology of the Diseases of Bones. By Arthur E. Hertzler, M.D. Philadelphia, J. B. Lippincott Company, 1931.

The author has confined this work to the surgical pathology of bone and presented this under two heads: Diseases of Bone, and Tumors of Bone. The term "surgical pathology" is evidently employed to designate the various forms which may be placed in this one group and presents a particular aspect to the active surgeon. Under the head of Diseases of Bone are considered the acute and chronic inflammations and the results of the specific infections and those of unknown origin,—such as Köhler's disease, etc. The pathogenesis, as well as the pathology, is discussed in detail and the scope of the work is most comprehensive. This is supplemented by very numerous and excellent illustrations; particularly are the x-rays of the acute and chronic inflammations of bone of value, demonstrating the various forms and the bone changes of osteomyelitis.

The author devotes a chapter in the second part to the classification and accepts that of the Registry Committee, which is given in detail. As in the first portion, the important forms are all considered. He has also added to the value and interest of the book by describing not only the more important and interesting subjects in these two groups, but also by considering with care the common and less serious and less important infections,—minor developments of bone diseases and growths.

The book is somewhat unusual in its complete scope. Taking as it does the subject of surgical pathology, it will be found most helpful to the practical surgeon.

School Orthopaedics. A Guide for Teachers. Compiled for The Devizes Orthopaedic Clinic by Miss L. S. Rolleston and Lieut.-Col. W. K. Steele, R.A.M.C., Springfield, Devizes, England, 1931. 2 shillings.

A small pamphlet of twenty-five pages designed to guide the physiotherapist in the principles and the practice of gymnastics for children of school age, especially for the improvement of posture and the amount as well as the kind of exercise. It will be found of value for such a purpose. The title is not well chosen. The term "orthopaedics" is always regrettable, and, in this case, does not sufficiently indicate the material in this pamphlet which is in the field of physiotherapy.

The Journal wishes to acknowledge the receipt of the following publications sent to the Editorial Department:

*Tratamento Cirurgico da Tuberculose Ossea. By Barros Lima. Recife, Imprensa Industrial, 1931.

*To be reviewed in a later issue of *The Journal*.

*Die Pseudarthrosen (Nebst Wahrscheinlichen Vorstadien) Nach Medialen Frakturen des Collum Femoris und Deren Behandlung. By H. Camitz. Acta Chirurgica Scandinavica, Vol. LXVIII, Supplementum XIX. Stockholm, 1931.

Röntgendiagnostik der Erkrankungen der Inneren Organe. By Emmerich Markovits. Leipzig, Georg Thieme, 1931.

*Untersuchungen über das Wirbelgleiten. By Hermann Meyer-Burgdorff. Leipzig, Georg Thieme, 1931.

Eine Studie des Nierentuberkulosematerials aus der Lunder Chirurgischen Klinik der Jahre 1901 bis Einschl. 1923. By Robert Ivarsson. Acta Chirurgica Scandinavica, Vol. LXVIII, Supplementum XVIII. Stockholm, 1931.

Slovanský Sborník Ortopedický. Brno, Czecho-Slovakia, Vol. VI, Nos. 4 and 5, 1931.

Chirurgia Clinica Polonica. Kraków, Vol. II, Fasc. 1, 1931.

Annaes Paulistas de Medicina e Cirurgia. S. Paulo, Brazil, Vol. XXII, Nos. 9, 11, and 12, September, November, and December, 1931.

Bullettino e Atti della Reale Accademia Medica di Roma. Rome, Vol. LVII, Fasc. 11, November 1931.

Anales del Servicio de Traumatología y Cirugía Ortopédica del Hospital Provincial. Valencia, 1930.

Ortopedia e Traumatologia dell' Apparato Motore. Rome, Vol. III, Fasc. 4, August 1931.

Norsk Magasin for Laegevidenskapen. Oslo, Vol. XCII, Nos. 6, 7, 8, 9, and 10, June, July, August, September, and October, 1931.

Om Steriliteten hos Kvinner, dens Årsaker og Behandling. By Harald Natvig. Tilleggshefte til Norsk Magasin for Laegevidenskapen. Oslo, Vol. XCII, No. 8, August 1931.

Årsberetning for Vestfold Fylkesykehus 1930. By Nikolai Paus. Bilag til Norsk Magasin for Laegevidenskapen, Vol. XCII, No. 10, October 1931.

Columbia University, New York Post-Graduate Medical School, Announcement of Courses 1931–1932. New York, 1931.

*Lehrbuch der Röntgendiagnostik. By H. R. Schinz, W. Baensch and E. Friedl. Ed. 3. 2 Vols. Leipzig, Georg Thieme, 1932.

*To be reviewed in a later issue of *The Journal.*

ON THE RELATIONSHIP BETWEEN THE PARATHYROID HORMONE AND THE GROWTH OF RAT CARCINOMA. T. S. Paik. *Am. J. Cancer,* XV, 2756, Oct. 1931.

The author injected several series of rats with parathyroid hormone after implantation of the Flexner-Jobling rat carcinoma. The rate of growth of the transplanted tumors was compared with that in a control group. He investigated similarly the effects of parathyroidectomy, parathyroid transplantation, and the injection of calcium chlorid solution. He concluded that the internal secretion of the parathyroid gland stimulates the development of rat carcinoma, but decrease of its internal secretion interferes with development of such a carcinoma. Calcium chlorid injections did not stimulate tumor growth.

(These experiments seem to be of interest because of the increasing recognition of the rôle of the parathyroid hormone in calcium metabolism.)—*Grantley W. Taylor, M.D., Boston, Mass.*

EDITORIAL: BIOPSY IN THE DIAGNOSIS OF TUMORS. *Am. J. Cancer,* XV, 2798, Oct. 1931.

In the course of discussing the uses and abuses of biopsy in general, Wood writes as follows in regard to bone conditions:

"Tumors of the bone offer a puzzling situation. There are many surgeons and radiologists who are opposed to biopsy. Nevertheless, if the diagnosis of a giant-cell tumor were made more frequently by biopsy procedure, many limbs would be saved

from amputation. On the other hand, is it wise to ray a bone tumor without knowing its nature? Many radiologists recommend that a supposed osteogenic sarcoma be rayed without a biopsy specimen. Here again the records are not quite clear, for the diagnosis of bone tumors is still far from perfect, both from the radiologic and histologic aspect, and while it would certainly seem that a mutilating operation should not be performed without a microscopic diagnosis to show its justification, neither should a patient be subjected to merely palliative radiation when the tumor might prove to be a type for which operation would be effective. Only a great deal more experience than we now possess will decide these questions."—*Grantley W. Taylor, M.D., Boston, Mass.*

THE OSSEOUS LESIONS OF CONGENITAL SYPHILIS. Summary and Conclusion in 102 Cases. Stafford McLean. *Am. J. Diseases of Children*, XLI, 1411, June 1931.

Seventy-one per cent. of the cases were in the first three months of life; eighteen and six-tenths per cent. in the second three months of life; ninety per cent. were not over six months of age.

The first three months is the age of election of all varieties of lesions. The first six months is the age of election for osteochondritis. The lesions that occur during the balance of the year are largely of the residual variety,—*i.e.*, periosteal cloaking, changes in trabeculation and the like. With advancing age, beginning at the sixth month, it is difficult to diagnose syphilis on roentgen evidence without collateral help. After the first and up to the fourth year of life, congenital syphilitic bone lesions are probably largely due to relapse of an incompletely healed lesion of early life. They are generally manifested as subperiosteal overgrowth, which looks like osteomyelitis. Favorite sites are the metacarpal bones and the phalanges, but other long or flat bones may be involved. It is doubtful whether the reparative splinting by abnormal production of subperiosteal bone in congenital syphilis differs greatly from that produced in any other type of disease which involves bone.

Syphilitic lesions are always distributed bilaterally, and in the first few months of life a lesion of a single bone, in our experience, has never been due to syphilis. Lesions of tarsals, metatarsals, metacarpals and phalanges do not occur in the first few months of life. Subperiosteal multilayered cloaking, the most spectacular roentgen observation, may be present on the most predominating lesion after the fourth month, and as the sole active lesion after the fifth month of life. At this age and up to the early part of the second year, it is of great diagnostic importance.

The author concludes that an unequivocal diagnosis of osseous syphilis can be made from the roentgenogram alone in certain types of lesions, and also that, in the preponderance of the cases, the roentgenogram divulged more information than the microscopic section.—*T. H. Vinke, M.D., Iowa City, Iowa.*

FRACTURE OF EXTERNAL SESAMOID BONE AT THE FIRST METATARSO-PHALANGEAL JOINT. Marcus H. Hobart. *Am. J. Surg.*, XIII, 242, Aug. 1931.

The author reports a case of a colored male who entered the Evanston Hospital Clinic, February 28, 1930, because of a left foot injured when a wheelbarrow full of planks turned over, striking him on the top of the foot forcibly. The history and physical findings were typical for fractured sesamoid bone. X-rays showed an oblique division. Bone was removed, which gave ample opportunity to confirm the diagnosis through pathological laboratory.

Patient was operated upon April 3, 1930, cast was removed April 28, 1930, and patient went back to work cured, May 5, 1930.—*T. L. Waring, M.D., Iowa City, Iowa.*

CA-GEHALT DES BLUTES UND CHRONISCHER GELENK-RHEUMATISMUS (The Calcium Contents of the Blood in Chronic Articular Rheumatism). M. Bastos und L. Mazo. *Arch. f. Klin. Chir.*, CLXI, 222, 1930.

The material investigated is as follows: twelve cases of ankylosing polyarthritis; ten cases in monarticular arthritis deformans; three cases with progressing, non-ankylosing arthritis deformans; and eight cases with rheumatoid or postinfectious secondary

arthritis. The examination of the cases of monarticular arthritis shows that increase of the calcium value stands in relation to the degree of bony destruction and new bone formation in the joint. The highest values were thirteen and eighty-six hundredths; this case was an arthritis deformans with excessive deformations, a marginal exostosis and free joint bodies. In rheumatoid arthritis without extensive bony lesions, the values were normal. In the ankylosing type of arthritis there were also found increased values of the calcium contents. The authors ascribe to the mobilization of the organic calcium the changes occurring in the ankylosing type as well as in the monarticular arthritis deformans. The authors further have found a slight diminution in the calcium contents in cases of tuberculous arthritis. There were, in two cases, extensive cyst formations of the bone, and the calcium values were also considerably increased, more than thirteen milligrams per 100 cubic centimeters of blood. The authors refer to the observation of Bach regarding the changes of the calcium contents in the blood during the period of repair of bone fractures. This author found that the calcium content of the blood in the first eighteen to twenty-two days increases over the normal at the ratio of ten to eight. Segovia, who investigated the calcium mobilization after fractures, comes to the conclusion that the calcium necessary for consolidation is derived from the region of the fractures themselves; an opinion which is also shared by Leriche and Policard. The bone is a storeroom of the calcium necessary for repair, comparable to the storage of the glycogen in the liver. Calcium can be mobilized without the necessity of any changes in the calcium quantities induced by food, which shows stability of the calcium equilibrium under normal conditions.

In conclusion, the authors maintain that the calcium values are constant in the normal, as well as in cases with articular rheumatism, but that, parallel with the bony changes in the skeleton, elevations of the calcium balance occur, which the authors consider not as the cause but the effect of the morbid process.—*A. Steindler, M.D., Iowa City, Iowa.*

Das Halsrippensyndrom und Seine Chirurgische Behandlung (The Cervical Rib Syndrome and Its Surgical Treatment). H. Jacobsohn. *Arch. f. Klin. Chir.*, CLXI, 398, 1930.

The author gives a very thorough review of the entire literature on cervical rib. He points out that one may speak of a cervical rib syndrome without cervical rib, and that satisfactory therapeutic results were not obtained until one was ready to operate, even without positive x-ray findings; a viewpoint which was substantiated by Sargent in 1913 in a report on thirty-four cervical rib operations. Sargent found, in cases of hypertrophic transverse processes, a fibrous band uniting these with the first rib. He noted that the band became tight in inspiration and caused pressure upon the plexus. Such a band from the transverse processes of the seventh cervical to the first rib was also found by Law, and in some cases the transverse processes appeared entirely normal.

A very substantial simplification of the surgical treatment of the cervical rib syndrome was brought about by the publications of Adson and Coffey in 1926, they having observed that plexus and subclavian artery were compressed between cervical rib or its ligamentous extension and the anterior scalenus muscle. With eight successful operations in the literature, the author believes that the operation is fully justified if undertaken before the irreparable changes of nerves and vessels have appeared. This operation may also be carried out as a preliminary operation and be followed by the removal of the cervical rib in case the clinical symptoms do not fully subside.—*A. Steindler, M.D., Iowa City, Iowa.*

Seltene Ursache einer Mauseinklemmung im Kniegelenk, ein Beitrag zur Klinik der Xanthomatösen Riesenzellgranulome (Unusual Cause of Joint Body Impingement in the Knee Joint. Xanthomatous Giant Cell Granuloma). W. Latten. *Arch. f. Klin. Chir.*, CLXI, 416, 1930.

The offending formation was a tumor in the knee joint, the size of a prune, of yellowish-brown color, soft consistency, starting from the meniscus or from the neighboring portions of the joint capsule. The tumor proved to be a xanthomatous giant-cell

granuloma. Such cases of xanthomatous giant-cell granulomata *in joints,* which produce typical impingement symptoms, have been described in the literature repeatedly, and the author quotes a number of references to the literature. A blood examination of the patient shows 220 milligrams of cholesterin,—that is, a marked hypercholesterinaemia, and the author believes that this considerable increase of cholesterin in the blood forms the basis for accumulation of lipoid xanthomata in the granulomatous structures.—*A. Steindler, M.D., Iowa City, Iowa.*

Über Beziehungen der Knochenbruchheilung zu Chemischen Veränderungen im Blute und ihre Beeinflussung durch Calcium-Vitamin-Behandlung (Healing of Fractures in Their Relation to Chemical Changes in the Blood and Their Reaction to Calcium Vitamin Treatment). L. Pincussen und B. Neuman. *Arch. f. Klin. Chir.*, CLXV, 483, 1931.

In experiments on rabbits and in the large majority of clinical investigations, it was shown that in fractures there is a marked shifting of actions in the blood. This in animals affects mostly potassium; in man, magnesium. After administration of a calcium-vitamin preparation (*pro ossa*), these fluctuations are definitely decreased and the curves showing the relationship to each other are noticeably more regular. The clearly demonstrable improvement by treatment in animals and acceleration of callus formation seem to be present also in man.—*R. J. Dittrich, M.D., Wichita, Kansas.*

The Union of Grafts of Live and of Preserved Fascia with Muscle. S. L. Haas *Arch. Surg.*, XXIII, 571, 1931.

Seven experiments were performed in which a piece of fascia lata that had been preserved in alcohol was transplanted in place of a piece of hamstring tendon and muscle removed from a dog. Examination at various periods, following the operation in the different animals, showed that union was almost secure after twenty-two days and with the lapse of further time the union was complete. Microscopic examination showed that the endomysium and perimysium played the major rôle in the union. There was no evidence of foreign-body reaction or absorption. Grossly the transformed tissue did not tend to make a firm, tendinous structure, but in general was somewhat gelatinous (oedematous). In this respect it differed from live fascia used as the graft, in that the live fascia was more tendinous and retained more of its elasticity. Microscopically there was no apparent difference.

The author concludes that, "Dead, preserved fascia may be used clinically for union with a muscle, but it seems advisable to utilize the live fascia if possible, because the latter appears to be transformed into tendinous tissue more readily."—*Marcus Schwartz, M.D., Baltimore, Md.*

Skeletal Metastasis Arising from Carcinoma and from Sarcoma. Murray M. Copeland. *Arch. Surg.*, XXIII, 581, Oct. 1931.

This article constitutes a comprehensive and exhaustive study of 334 cases of skeletal metastasis from malignant neoplasms. The material was obtained from the Department of Surgery and the Surgical Pathological Laboratory of the Johns Hopkins Hospital and University. The important clinical features, the x-ray appearance, the incidence of metastasis of the various types, the incidence of involvement of the various bones and the histogenesis are set forth. From this data an attempt is made to draw some conclusions as to the mode of metastasis and to determine the most satisfactory method of treatment.

A list is given of the parts involved by the metastases in cases of breast carcinoma, hypernephroma, and primary malignancies of various organs.

The methods of metastasis as suggested by a study of these cases are discussed. In general, both an embolic (hematogenous) and a lymphatic mode of involvement are responsible for metastatic lesions of the bone. The particular circumstances of each case, such as the duration and the character of the primary tumor, together with the method of treatment, will often determine the mode of metastasis.—*Marcus Schwartz, M.D., Baltimore, Md.*

Intracapsular Fractures of the Neck of the Femur. Treatment by Internal Fixation. M. N. Smith-Petersen, Edwin F. Cave, and George W. VanGorder. *Arch. Surg.*, XXIII, 715, Nov. 1931.

The functional impairment resulting from immobilization has proven to be a major handicap to the treatment of fractures of the neck of the femur by methods of external fixation. Internal fixation has proven unsatisfactory because: first, the usual round or square nail fails to hold the fragments in position, and, second because the bulk of the nail destroys considerable bony tissue and causes localized necrosis.

To combat these difficulties the authors have developed a flanged nail which reduces the tissue damage to a minimum and at the same time locks the fragments securely. The operative technique for the use of the nail and the instruments necessary for this operation are clearly described. The exposure of the fragments is accomplished by a modification of the Smith-Petersen hip approach. The authors stress the point that accurate reduction of the fracture, correct placement of the nail, and close impaction of the fragments are necessary for success. Complete case reports of the first twenty-four patients treated by this method are given. Eighteen of these patients were over fifty years of age. The operative shock was not great, so that no immediate postoperative deaths ensued. Two patients died from sepsis. Seventy-five per cent. of the cases gave good bony union; fifteen per cent. non-union.

It is pointed out that this procedure did not necessitate plaster-of-Paris immobilization after the operation, and that early functional restoration took place. The technique was useful for old non-unions as well as for recent fractures.

The article is well written, well illustrated, and quite convincing.—*I. William Nachlas, M.D., Baltimore, Md.*

Zur Ätiologie und Therapie der Ischämischen Lähmung des Vorderarmes (Etiology and Therapy of Ischaemic Paralysis of the Forearm). Wilhelm Bittner. *Bruns Beitr. z. Klin. Chir.*, CLII, 510, 1931.

Of the four cases here reported, three were observed among 2850 cases of fracture of the upper arm and forearm. Etiologically, in addition to a certain predisposition, a hematoma is a decisive factor. The latter, by compression of the vessels and nerves, produces an ischaemia and later, by fibrous degeneration of the muscles, leads to scar formation and thus injures the nerves.

The treatment in the earliest stages should consist of removing the hematoma by puncture or incision. After the contracture has developed, the most successful results are obtained by early neurolysis. Of the four cases, one was treated by resection of the radius and ulna, one by neurolysis of the median nerve, and two by neurolysis of the ulnar nerve and lengthening of the flexor tendons.—*R. J. Dittrich, M.D., Wichita, Kansas.*

Femoral Condylitis. Merrill Coleman Mensor. *California and Western Med.*, XXXV, 121, Aug. 1931.

The author discusses two cases presenting symptoms of inflammation over a small area two centimeters above the joint line on the external condyle of the right femur. The x-ray revealed in each case a small calcified spot apparently separated from the inflamed area. There was no history of trauma in either case, the pain appearing suddenly, accompanied by oedema, local heat, fever and leucocytosis. One case was operated upon, but no pus or fluid was found; the culture demonstrated the staphylococcus albus. The other case was treated by continuous heat and recovered as quickly as the first. The author believes this to be a definite selective osteomyelitis of low virulence which may readily be mistaken for injury in industrial practice.—*Charles Lyle Hawk, M.D., Los Angeles, California.*

The Physiology of the Parathyroid Glands. J. B. Collip. *Canadian Med. Assn. J.*, XXIV, 646, May 1931.

This is a report of the more recent developments in this field.

The function of the parathyroid gland is apparently the maintenance of a definite level of total calcium in the plasma. Hunter has demonstrated a specific effect of the parathyroid hormone on the activity of the osteoclasts of the bone. It has been shown

that increase in the blood serum calcium following injection of parathyroid hormone is due to the mobilization of this element from the bone reservoirs.

The biochemistry of calcium is considered.

In discussing the absorption of calcium, he points out that it is probably absorbed in the ionized form. It has been shown that vitamin D influences directly the absorptive process for calcium. The fecal calcium represents both the unabsorbed calcium of the food and re-excreted calcium. It is excreted by the kidney in amounts of from one-tenth to five-tenths grams per day on a normal diet.

The relation of inorganic phosphorus to calcium is discussed. The preparation of the internal secretion of the parathyroid gland is presented. The physiological effect of the hormone is that of a mobilizer of the blood plasma calcium. The source of this additional calcium in the blood stream is bone. The effect of the progressive changes in blood chemistry during parathyroid hormone overdosage has been studied. The active extract is specific for the treatment of parathyroid tetany.

Aub has shown that humans, when treated over a prolonged period with the hormone, develop a condition of immunity to the specific calcium-mobilizing effect. Calcium metabolism is also affected by diet, acidosis, alkalosis, exophthalmic goiter, and vitamin D. These are considered.

He next gives clinical conditions in which calcium metabolism or parathyroid function is disturbed.—*M. E. Pusitz, M.D., Iowa City, Iowa.*

AVULSION OF THE LESSER TROCHANTER OF THE FEMUR. J. S. McEachern and H. N. Jennings. *Canadian Med. Assn. J.*, XXV, 449, Oct, 1931.

Gives details of a case of the injury in a boy of fourteen. Patient was put to bed with the right leg suspended in a bent Thomas frame. After five weeks he was allowed up with crutches. Six weeks later the boy complained of no discomfort.

Avulsion of the lesser trochanter of the femur is a rare injury. Metcalfe collected eleven cases from the literature and added two of his own. Treatment by fixation of the hip in flexion has given good results in nearly all cases. One youth developed an infected hematoma and died from tetanus. In another case operative fixation of the lesion was done and that patient also died.—*A. Gibson, M.D., Winnipeg, Canada.*

TRAUMATIC ANEURYSM OF THE SUBCLAVIAN ARTERY AS A LATE COMPLICATION OF FRACTURED CLAVICLE. E. H. Cayford and F. J. Tees. *Canadian Med. Assn. J.*, XXV, 450, Oct. 1931.

Fractured clavicle is very rarely followed by any sequelae of importance. When the artery is injured, the sequence of events according to Keen is as follows: Injury of the vessel wall allows leakage into the wall; a thrombus then follows, is organized into scar tissue, which is unable to withstand the pressure of the blood, and stretches, forming a false aneurysm.

Case report is given of an aneurysm of the subclavian artery, following a football injury, operated upon twice—in the second operation by ligature of the artery—with recovery. When last seen, about four months after the operation, there was no evidence of motor or sensory disturbance and patient enjoyed full use of the arm.

It is better to ligate both artery and vein than artery alone. The operation emphasized the difficulty of intrasaccular repair of aneurysm. There may be leakage due to dissection of arterial blood through the faulty repair of low-grade tissue, or there may be dilatation at the suture line. With the experience of this case and the help of the available literature, it would seem safer to adopt a less conservative procedure and to tie the vessel proximal to the aneurysm in the first instance. The present case is convincing evidence that the corresponding vein should be tied as well, and that the ligature should be above the arterial one.

Klinischer und Experimenteller Beitrag zur Peritendinitis Crepitans (Clinical and Experimental Contribution to Peritendinitis Crepitans). Paul Moritsch und Alice Blau. *Deutsch. Zeitschr. f. Chir.*, CCXXXI, 550, 1931.

Peritendinitis crepitans was found in one and thirty-nine hundredths per cent. of 16,900 cases. Brief clinical records of twenty-six patients are reported. In twenty-two cases the condition was found in the forearm and hand, in four cases in the lower extremity. The extensors of the wrist and fingers were affected in twenty-one cases. The affection is more common during cold weather.

Etiologically, the most important factor is a combination of infection of the nose or throat and trauma (overexertion). The clinical features are pain, swelling, and crepitation, involving one or more tendons. Therapy consists of immobilization of the affected part, and treatment of the acute infections. The average duration is two to three weeks.

The authors succeeded in producing the clinical picture experimentally in rabbits. In addition to fatiguing of the muscle by electrical stimulation, it was necessary to produce a toxaemia by injection of typhoid vaccine or bacteria.—*R. J. Dittrich, M.D., Wichita, Kansas.*

Der Ablauf des Mineralstoffwechsels und Dessen Beziehungen zur Inneren Sekretion bei Knochenbrüchen (Metabolism of Minerals and Its Relation to Internal Secretion in Fractures). Hans Stocker. *Deutsch. Zeitschr. f. Chir.*, CCXXXI, 714, 1931.

By investigations and observations in fractures with normal and delayed union, an experimental and clinical study was made of the metabolism of minerals and its dependence on the activity of the endocrine glands. In addition, investigations were made on the influence of calcium pho·phorus or thymus therapy on the healing of fractures.

By microchemical methods, determinations were made of the inorganic calcium and phosphorus of the blood and the urine, and it was demonstrated that in fractures with normal union, a hypercalcaemia is produced, which persists until the osteoid callus has been changed to bone tissue. No change was noted in the phosphorus content.

With delayed union similar changes were found in the blood; however, the hypercalcaemia persisted for a longer period and a more pronounced excretion of calcium was found in the urine.

The statement of Peterson that the product of calcium and phosphorus was less than thirty in case of delayed union, could not be confirmed. As the actual cause of delayed callus formation, the disturbance is not one of metabolism, but rather is at the site of the fracture. The nature of the disturbance is not definitely known, but probably consists of injury to the blood vessels, which would prevent an adequate supply of calcium.

Experimentally the influence of therapeutic measures on fractures was studied in young, non-thymectomized dogs. A hastening of the consolidation process could not be produced either by administration of calcium and phosphorus, or by injection of thymus preparation.

In patients who had no other disease, and in whom delay of union was noted, administration of thymus produced an enormous shifting of the inorganic elements of the blood and urine, consisting of an increased mobilization and retention of short duration. Calcium phosphate could not be deposited at the site of the fracture, due apparently to poor circulation, and as a result there was an increased excretion of calcium and phosphorus. Practically, the results were negative also following thymus administration.

In general, calcium and phosphorus metabolism is dependent on the function of the glands of internal secretion, since apparently by the regulatory activity of the epithelial bodies system, sufficient amounts of mineral salts are absorbed and placed at the disposal of the cell, whereas the thymus affects the chemistry and, by checking the formation of acids (nuclein-phosphoric acid), provides for the presence of calcium-destroying agents (alkalies). With a hyperacidity of the organism a lack of calcium is brought about by increased excretion of calcium and phosphorus.

The action of thymus extract depends on an increased function of the thymus gland, which results in a reduction of the acids in the organism. This condition produces, accordingly, an increased mobilization of calcium and phosphorus in the tissues. The influences of other endocrine organs on mineral metabolism must be considered, but are completely unexplained.

The analysis and findings of mineral metabolism in cases of delayed union demonstrated clearly that, therapeutically, the only available measures are those directed toward the seat of the disturbance, the site of the fracture, since calcium deposition can result only from alteration of unfavo able conditions at that point.—*R. J. Dittrich, M.D., Wichita, Kansas.*

ZUR ARTHRODESENFRAGE (Problem of Arthrodesi). Fritz Lange. *Deutsch. Zeitschr. f. Chir.*, CCXXXII, 4, 1931.

Arthrodesis of the elbow, hip, and knee joints is rejected. In the wrist joint it is indicated in the absence of any other substitute for the paralyzed muscles. In the shoulder joint it yields excellent results in cases of deltoid paralysis. The extensively used and indiscriminate ankylosis of four to eight joints in the foot is condemned. The author recommends limiting the operative procedure to the joint which produces the flail foot. In the ankle joint passive mobility of five to ten degrees should be obtained; in the subastragaloid joint the aim should be complete ankylosis.—*R. J. Dittrich, M.D., Wichita, Kansas.*

ERFAHRUNGEN ÜBER DIE RADIKALOPERATION DER ANGEBORENEN HÜFTVERRENKUNG BEI ERWACHSENEN (Experiences with Open Operation in Congenital Dislocation of the Hip in Adults). Carl Deutschländer. *Deutsch. Zeitschr. f. Chir.*, CCXXXII, 52, 1931.

The author makes an analysis of twenty-three cases of congenital dislocation of the hip in adults subjected to operation. Of these, nineteen were end results. The ages varied from eighteen to sixty-five years. The procedure is very satisfactory and not attended with danger. Emphasis is placed on the importance of overcoming obstacles to correction by means of the scalpel, rather than blind force.

A two-stage operation is employed. The preliminary operation consists of overcoming muscular resistance by tenotomies of the adductors biceps femoris and rectus femoris, and application of skeletal traction. This is followed in ten to fourteen days by the main operation.

Of the nineteen cases, one died and two resulted in ankylosis. Two-thirds of the cases resulted in complete or satisfactory reposition and about one-fourth showed a transposition.

In contrast to the anatomical results, the functional results—based on elimination of pain, shortening, and lordosis, and restoration of a stable gait—were more favorable. Restoration of joint mobility was excellent in eleven cases and satisfactory in six cases. The greatest range of motion was found, contrary to expectations, in the cases of eccentric repositions and transpositions, rather than in those of concentric reductions.—*R. J. Dittrich, M.D., Wichita, Kansas.*

CALCIFIED DEPOSITS IN SUBDELTOID BURSITIS. E. B. Mumford and Florence J. Martin. *J. Am. Med. Assn.*, XCVII, 690, Sept. 5, 1931.

The authors here discuss only that phase of subdeltoid bursitis in which calcareous deposits were present.

A brief review of the anatomy and symptoms is given and the following conclusions made after a study of fourteen of their own cases:

1. The etiology is indefinite, but repeated mild traumata with the arm abducted may be an important factor, or a single mild or severe trauma leading to an injury of

the tendons in this region may be a contributory cause. Why a calcium salt should be deposited in some cases, or in this particular bursa, and not in others is not known.

2. The calcareous deposit has no relation to the pain, other than it may possibly lead to further trauma, producing an acute attack; however, it may remain after the symptoms have disappeared.

3. If the deposit is a calcium salt it reacts unlike any other calcium deposit,—it may form without an apparent cause; it is often fragmented; and it will disappear under the influence of diathermy.

4. Conservative treatment in the form of diathermy treatment should be instituted and surgical intervention should never be advised.—*Ruth Jackson, M.D., Dallas, Texas.*

SURGICAL TREATMENT OF CHRONIC ARTHRITIS. Henry W. Meyerding. *J. Am. Med. Assn.*, XCVII, 751, Sept. 12, 1931.

An interesting treatise on the surgical possibilities in the treatment of chronic arthritis, with a report of seven cases treated by the author, the results of which were gratifying and offer encouragement in the treatment of deformities associated with chronic arthritis.

The advantages of measures to prevent contractures in the early stages of arthritis are discussed: synovectomy, capsuloplasty, capsulotomy, tenotomy, osteotomy, arthroplasty, arthrodesis, and sympathetic ganglionectomy and trunk resection. All have their place in the surgical reconstructive program for restoration of function in the arthritically disabled individual.—*Ruth Jackson M.D., Dallas, Texas.*

THE CURE OF INFANTILE RICKETS WITH TUNGSTEN-FILAMENT RADIATION. Henry J. Gerstenberger and Arthur J. Horesh. *J. Am. Med. Assn.* XCVII 766, Sept. 12, 1931.

The possibilities of "dual-purpose lighting" have been tested by the authors and found promising. Twelve-hour exposures to suberythemal doses of tungsten-filament radiation, produced by a 500-watt CX Mazda lamp suspended in oxidized aluminum reflectors from the ceiling of a room at a distance of five and one-half feet above the bed level, were given to two colored and one white moderately severe rachitic infants, over a period of ninety days, resulting in a complete cure as shown by blood and roentgen examinations.

The infants were dressed in shirt, diaper, and booties; goggles were not necessary. A definite pigmentation gradually developed over the exposed areas. Infections of the upper respiratory tract, which were present when the observations were begun, were not prevented from recurring, although they seemed to have become less severe.

The results of these observations indicate that "dual-purpose lighting", as proposed by Luckiesh probably will become practically feasible.—*Ruth Jackson, M.D., Dallas, Texas.*

RESULTS OF TREATMENT OF THROMBO-ANGIITIS OBLITERANS BY FOREIGN PROTEIN. Nelson W. Barker. *J. Am. Med. Assn.*, XCVII, 841, Sept. 19, 1931.

The results of 150 cases of thrombo-angiitis obliterans, treated by intravenous injections of foreign protein in the form of typhoid vaccines, lead the author to conclude that such treatment is valuable chiefly to carry a patient through one of the critical periods of exacerbation, provided gangrene has not already become too extensive. Once he has been carried through such a period, other measures should be substituted,—such as, education regarding the disease; protection of the extremities from mechanical,thermol, and chemical injury; special hygiene of the feet; limited activity; abstinence from tobacco; postural exercises; contrast baths; and, in certain selected cases, sympathetic ganglionectomy. The best results were secured in cases in which there was rest pain, with or without ulcers or limited gangrene.—*Ruth Jackson, M.D., Dallas, Texas.*

EXPERIENCES WITH PERIARTERIAL SYMPATHECTOMY IN FRACTURES OF THE LOWER EXTREMITY. Ralph Colp and Sigmund Mage. *J. Am. Med. Assn.*, XCVII, 1069, Oct. 10, 1931.

The belief that one of the greatest practical problems in industry is the speedy rehabilitation and economic restoration of the injured led the authors to perform periarterial sympathectomies on a group of patients having fractures of the lower extremities. In a series of seven recent fractures of the lower extremity, *this operation resulted in an average diminution of eleven days in obtaining clinical union*, of nineteen days in hospitalization, and no case showed a tendency toward delayed union. In a series of ten cases of delayed union in fractures of the lower extremity which were united after an average of seventy days, *clinical union resulted twenty-one days after sympathectomy.*

The authors feel that these results justify a further trial of this operation in recent fractures and in those in which union appears to be delayed.—*Ruth Jackson, M.D., Dallas, Texas.*

LA RÉSECTION ARTHROPLASTIQUE DE LA HANCHE (Arthroplastic Resection of the Hip). Paul Mathieu. *J. de Chir.*, XXXVIII, 1, July 1931.

The author recommends the reconstruction operation of Whitman for ununited fractures of the neck of the femur, old arthritis of the hip, traumatic or pathological dislocations which are not reducible, and ankylosis of the hip following arthritis or adolescent coxa vara. He describes the technique in detail.

The incision recommended is an anterior incision, extending from the anterior superior spine downward about twelve centimeters, and the lower angle of the incision is extended directly backward to beyond the posterior border of the iliotibial band. The anterior incision is carried downward between the sartorius and the tensor fascia lata. This gives a flap which, when folded upward and backward, exposes the great trochanter and the anterior surface of the hip joint. He recommends making a wide incision into the capsule of the hip and recommends cutting the head from the neck, either with a Gigli saw or a curved osteotome, before the head is removed, as violent manipulations necessary to exarticulate the head may throw the patient into profound shock.

The paper is unusually well illustrated and every detail of the operation for arthroplastic resection is clearly shown. A case of pseudarthrosis through the neck of the femur and a case of osteoarthritis are reported in detail and the results in each were good.—*J. Albert Key, M.D., St. Louis, Missouri.*

L'ARTHROTOMIE DE LA HANCHE PAR LE PROCÉDÉ D'OLLIER MODIFIÉ (Arthrotomy of the Hip by the Modification of Ollier's Method). J. Gatellier et Merle D'Aubigné. *J. de Chir.*, XXXVIII, 24, July 1931.

Ollier's incision is a curved lateral incision which is convex downward, the lower border of the incision being slightly below the level of the great trochanter. The trochanter is sectioned and folded upward, thus exposing the top of the hip joint. The authors have modified this incision by making it considerably larger, beginning at the anterior limb in the vicinity of the anterior superior spine and curving backward and downward to a point about two inches below the tip of the trochanter and upward and backward for a distance approximately equal to the length of the anterior incision. The dissection of the anterior limb is carried down between the tensor fascia lata and gluteus medius and the posterior limb is carried down between the gluteus medius and maximus. These two incisions are then further deepened and the capsule of the hip joint is opened in line with the skin incisions in front and behind. A Gigli saw is now introduced into the capsule and the trochanter is cut very obliquely, leaving the upper portion of the capsule attached to the trochanter. The muscles attached to the trochanter and upper portion of the capsule are retracted upward, giving wide exposure not only to the top of the hip joint, but also to the anterior and posterior surfaces. In operating for fracture of the neck of the femur, the authors place a bone peg through the stump of the neck, the peg entering at a point from which the trochanter has been removed and passing obliquely

downward through the neck to enter the head. The incision is closed in layers, the capsule being sutured and the trochanter being reattached by means of a screw. They recommend the incision for fractures of the neck of the femur, reconstruction operations, and arthroplasties and state that in their experience the operation is practically devoid of shock.—*J. Albert Key, M.D., St. Louis, Missouri.*

Traitement Chirurgical Immédiat des Entorses Graves du Genou (Immediate Surgical Treatment in Severe Sprains of the Knee). P. Oudard. *J. de Chir.*, XXXVIII, 321, Sept. 1931.

The author reports four personal cases and three cases from the literature in which severe injuries to the knee, with tearing of the lateral ligaments and with or without injuries to the crucial ligaments and semilunar cartilages, have been treated by immediate operation with suture of the torn lateral ligaments. It is his opinion that immediate surgery in these cases gives much better results than does conservative treatment, because he feels that it is asking too much to expect large ligaments like the lateral ligaments of the knee to heal by simple immobilization. The end results in the cases reported are unusually good for the type of injury under consideration.—*J. Albert Key, M.D., St. Louis, Missouri.*

Du Traitement de la Luxation Récidivante de l'Épaule par l'Opération de Oudard Modifiée (Treatment of Recurrent Luxation of the Shoulder by a Modification of the Operation of Oudard). Jazques-Charles Bloch et Olivier Guihéneuc. *J. de Chir.*, XXXVIII, 333, Sept. 1931.

The principle of Oudard's operation is a lengthening of the coracoid process so that it extends anteriorly and prevents the head of the humerus from slipping forward. In the authors' operation the patient is placed in a position with the arm abducted ninety degrees and an incision between the deltoid and pectoralis major muscles is carried down to expose the coracoid. This is then sectioned very obliquely from above downward and backward. The section of the process is performed by means of a series of small drill holes and the remaining bone is then cut with a thin osteotome. The tip and lower portion of the process is then slid forward about four centimeters, where it is tied to the base with circular silk ligatures or wire.

The authors report fifteen cases by Oudard and four of their own, none of which have any recurrence. This is an operation with which American surgeons are unfamiliar, but one which seems to be worth considering.—*J. Albert Key, M.D., St. Louis, Missouri.*

The Treatment of Tuberculous Joints with Cyanid of Gold. M. Friedland. *J. Sovremmennoi Chir.*, VI, 329, 1931.

Since 1925 the author has applied the above preparation in the form of injections into the diseased areas of bone tuberculosis. In order to obtain a relatively perfect local effect from the gold preparation, he applies a Bier's compression bandage, which insures a bloodless area and prevents the disintegrating action of the blood on the cyanid of gold.

In this bloodless area surrounding the tuberculosis focus he injects subperiostially a 1:1000 solution of aurum kali cyanatum with a fifty per cent. solution of novocain. The dose varies from 0.003 to 0.05 cubic centimeters in children to 0.01 to 0.2 in adults. In children he at times applies a general anaesthesia and omits the local novocain. The Esmarch tube and the elastic bandage are left on for about fifteen minutes after the injection.

At the beginning there is noticeable an increase of the inflammatory process. This subsides in a few days. The injections are repeated once or twice, giving all together not more than three injections at one-week intervals. This method has been used by the author on about fifty patients from four to thirty years of age. He has obtained eighty-four per cent. permanent results.

He attributes this favorable effect to the influence of gold cyanid on the tubercle bacilli, as well as to the general reaction upon the constitution. However, this method should only be regarded as an adjunct to other methods of treatment; it aids in shortening the time of recovery.—*A. Gottlieb, M.D., Los Angeles, California.*

A CASE OF IMPENDING VOLKMANN'S ISCHAEMIC CONTRACTURE TREATED BY INCISION OF THE DEEP FASCIA. C. W. Flemming. *Lancet*, II, 293, Aug. 8, 1931.

Treatment of this condition by incision of the deep fascia is now a well established procedure, but instances of the operation are rather scant in the literature. A case is described of a boy, aged ten, who sustained a supracondylar fracture of the left humerus. Five hours after the accident there was considerable swelling about the elbow; the radial pulse was easily felt. Forty-eight hours after the accident there was no pulsation at the wrist.

A longitudinal incison was made in the middle line over the antecubital fossa. The subcutaneous tissues were infiltrated with blood. When incised, the deep fascia split apart about three-fourths inch, and the muscles bulged into the gap. The muscle bellies were very pale, but there was no infiltration of blood into them. The wound was left open, and the arm put on a pillow. Next day, the radial pulse was still impalpable and there was pain in the forearm, but there was a full range of the fingers and wrist.

Nine months after the accident the range of movement at the elbow was ninety degrees' flexion and full extension; there was no limitation of pronation or of supination, and no pain.—*A. Gibson, M.D., Winnipeg, Canada.*

OBSERVATIONS ON THE PRODUCTION OF ANTIPOLIOMYELITIS SERUM IN HORSES AND THE DISTRIBUTION OF THE ANTIBODY AMONG THE SERUM FRACTIONS. R. W. Fairbrother and W. J. T. Morgan. *Lancet*, II, 584, Sept. 12, 1931.

An antiviral serum of marked activity against the poliomyelitis virus has been produced by the intramuscular inoculation of two horses with the living virus. Two other animals completely failed to respond.

It is well known that the variable nature of the disease makes it difficult to assess the value of specific forms of treatment in the prevention of paralysis, and it is generally believed that specific treatment with convalescent serum is likely to be of small value when given after the paralysis has appeared. It may be expected, however, that the renewed interest aroused by the production of antiviral serum in large animals may lead to much needed information on these debated points—*A. Gibson, M.D., Winnipeg, Canada.*

TRANSPLANTATION OF BONE. W. E. Gallie. *Lancet*, II, 687, Sept. 26, 1931.

Among the causes of failure, infection is the most frequent. A bone transplant ultimately dies and undergoes absorption in its bed. Success in bone grafting depends on (1) primary union, (2) firm healing of graft to bed, (3) final union of fragments to one another. The commonest defect is in not securing contact of graft to bed over a sufficient area; in radius or ulna, a graft should be embedded one and one-half inches into each fragment; in the tibia, two and one-half inches at each end. Another common error is insufficiently close contact between the graft and its bed; even a gap of one-eighth of an inch would cause non-union. Immobilization is of even greater importance in a graft than in a simple fracture. The graft must be placed in a vascular bed, and accordingly the sclerosed ends of the fragments are unsatisfactory, and should be removed. Mere removal of these ends is not enough. Adequate incision is essential; the periosteum should not be stripped more than necessary. For slender bones the diamond graft is suitable; the intramedullary peg is usually unsatisfactory. A graft of the whole fibula for the femur does not have this drawback as its own medullary cavity is available for the migration of osteogenetic tissue. For the tibia, the inlay-graft is best. The graft itself must contain living elements, be strong enough to act as a tem-

porary splint, and resist disintegration until sufficient new bone has been laid down to prevent its collapse. In the mandible the rib graft gives good results. Shortening of a bone was strongly recommended so as to get end-to-end union rather than an attempt to bridge a wide gap. When bridging was unavoidable, a diamond graft was used surrounded by multiple slivers and crushed cancellous bone.—*A. Gibson, M.D., Winnipeg, Canada.*

On the Apparent Diminution in Skeletal Muscle Tonus Following Removal of the Lumbar Sympathetic Trunk. Gilbert Phillips. *Med. J. of Australia*, I, 628, May 23, 1931.

The physiology of muscle tonus is reviewed and theories from those of Galen to the present-day physiologists are critically discussed.

In connection with the fact demonstrated by Sherrington, that the myotonic or stretch reaction of posture-maintaining muscles is dependent upon a proprioceptive reflex, the question has now arisen: "Do the postganglionic fibers of the sympathetic nervous system constitute the efferent limb of the reflex arc subserving tonus in skeletal muscle?"

Royle and Hunter believed that they did.

In the present investigation fifteen cases were used. In all, the left lumbar sympathetic tract was removed. In eight, decerebration was done at once, and in seven decerebration was done after an interval of three weeks.

In each animal the knee extensor was isolated from extraneous proprioceptive and exteroceptive reflex effects by section of all cutaneous nerves to both hind limbs, and tenotomy or motor nerve section of all the muscles in both hind limbs with exception of the vasticrurei and that branch of the femoral nerve by which they are innervated.

The posture and postural reflex actions were then examined. The results obtained are detailed and from them it is concluded that sympathetic nerves are not responsible for the maintenance of posture in skeletal muscles, since decerebrate rigidity develops and is maintained and postural reflex activity is present in a muscle deprived of its sympathetic innervation; and, secondly, that the excitability of proprioceptive reflex-activity is increased in a postural muscle after removal of the sympathetic nerves distributed to it.

It is suggested that the apparent diminution of tonus, or decreased resistance to a passive stretching force, following removal of the sympathetic innervation to a postural muscle, is due to an increased excitability of the nerve endings whose stimulation produces the lengthening reaction in the muscle. This increased excitability is due to vascular disturbance.

The conclusion is that the postganglionic fibers of the sympathetic nervous system do not constitute the efferent limb of the reflex arc subserving posture in skeletal muscle.—*Edward N. Reed, M.D., Santa Monica, California.*

Fracture of the Os Calcis by Muscle Action. Henry Milch. *Med. J. and Record*, CXXXIV, 327, 1931.

The author reports a case with fracture of the os calcis by muscle action in a man, aged forty-seven, chronically ill. He was subject to depressive fits following an attack of encephalitis three years previously. During one of these fits the patient fell down half a flight of stairs, and was unable to walk unassisted upstairs. Swelling and ecchymosis soon developed about the right ankle and heel. He was able to get out of bed at the end of six weeks, but on walking complained of pain in the heel and of a limp.

The height of the right heel was markedly increased and appeared to consist of two prominences separated by a slight furrow. On the apex of the upper prominence there was a small encrusted scab, a dirty gray ulcer. There was no apparent limitation of motion at the tibiotarsal or subastragaloid joints. Roentgenograms showed a transverse fracture of the posterior portion of the os calcis.

The mechanism of the fracture in this case was a result of several factors. With the anterior portion of the os calcis fixed by the body weight, the posterior portion was subjected to the distracting force of the Achilles tendon pulling upward and the immobilizing action of the intrinsic foot muscles tending to pull downward on the tuberosities of the calcaneum. The other factor was the diminished tensile strength of the bone as a result of arterial changes and lack of activity.—*Robert Zollinger, M.D., Cleveland, Ohio.*

A Mixed Form of Chronic Arthritis. Benjamin H. Archer. *Med. J. and Record*, CXXXIV, 344, 1931.

In a series of 1,459 cases of chronic arthritis the author found about fifty-three per cent. belonged to the chronic infectious group and twenty-five per cent. were cases of arthritis of the menopause. The object of the study was to determine whether the proliferative and degenerative lesions of chronic arthritis arose simultaneously as part of the same pathological condition, or whether one form of the disease was superimposed upon the other as two pathological entities. He found a mixed form of chronic arthritis characterized clinically by the presence of grating knee joints, Heberden's nodes, and fusiform fingers in approximately one per cent. of the 1,459 cases. The mixed form of chronic joint disease presented the typical pathological lesions of proliferative and degenerative arthritis in the same patient. The proliferative lesions appeared less virulent and progressive than in younger people. The degenerative lesions were similar to those present in the arthritis of the menopause. This form of arthritis appeared to be a combination of an inflammatory and a degenerative process.—*Robert Zollinger, M.D., Cleveland, Ohio.*

New Method of Employing Skeletal Traction. Roger Anderson. *Northwest Med.*, XXX, 444, Oct. 1931.

The author presents an original design of skeletal traction apparatus utilizing the sound leg as a means of traction. It consists of a stirrup-like splint which is incorporated in a cast enclosing the sound limb. A lateral extension carries an adjustable lever, one end of which is attached to the skeletal traction on the injured member. The sound leg therefore acts as an extension splint, and by means of the adjustable lever considerable variations of its length are obtained. The advantages claimed are its simplicity, making it appliable in bed under local anaesthesia and saving the surgeon's time. It cannot get out of order and the patient may sit up the day it is applied. He finds himself more comfortable and the hospital period is lessened.

The author has reduced fractures of the symphysis pubis, femoral neck, shaft of the femur, and the leg bones, and presents x-ray evidence in support of its effectiveness.—*Charles Lyle Hawk, M.D., Los Angeles, California.*

Intra-extra-articular Arthrodesis of the Hip Joint. V. D. Tchaklin. *Orthopaedia i Travmatologia*, I, 36, 1931.

The ordinary intra-articular arthrodesis in advanced cases of poliomyelitis does not produce always a firm ankylosis with good stability and absence of pain. The author devised a modification of the intra-articular operation and considers it successful in three cases operated upon by him. A curved Murphy incision is made over the hip joint. The glutei muscles are separated from the major trochanter. The trochanter is then osteotomized obliquely from the base upward and inward through the neck to the diaphysis. The joint is opened and the usual intra-articular arthrodesis is performed. Right above the acetabulum a small trough is made in the bone, the osteotomized part of the trochanter is turned 180 degrees, then moved into the trough and sewed with silk to the ilium and femur. The extremity is then held in ten to twenty degrees of abduction and twenty to thirty degrees of flexion for two months.—*Emanuel Kaplan, M.D., New York, N. Y.*

CHANGES IN BONE GROWTH UNDER THE INFLUENCE OF BONE TUBERCULOSIS. S. L. Tregubow. *Orthopaedia i Travmatologia*, II, 5, 1931.

Whenever a focus of lues, osteomyelitis, hemophilia and, particularly, of tuberculosis is located in the proximity of the epiphyseal line, a derangement of the bone growth is noticed; a lengthening of the diaphyses is observed, there is also an enlargement of the epiphyses accompanied frequently by an early maturity of the bone. These changes have been noticed in all the bones of the upper and lower extremities, also in the bones of the pelvis and are possible wherever the epiphyseal cartilage is still present. If the infection involves the epiphyseal line, the described changes do not occur. The explanation of this phenomenon lies in the irritation of the cartilage of the epiphyseal line, reflex manifestations, and possibly in some endocrine mechanism.—*Emanuel Kaplan, M.D., New York, N. Y.*

OPERATIVE TREATMENT OF ACQUIRED RADIAL CLUB-HAND. G. A. Ilin. *Orthopaedia i Travmatologia*, II, 51, 1931.

The author reviews different methods of operation, as described by various surgeons. In cases where the distal fragment of the radius is preserved, the author recommends his procedure which results in a fair range of motion, excluding pronation and supination of the forearm. The steps of the operation are: Incision over the medial side of the lower third of the ulna. The ulna is divided six centimeters above the distal end, the proximal end of the ulna is then shaped into a sharp point. The remaining distal fragment of the radius is brought out into the wound and reshaped. The sharpened proximal end of the ulna is then introduced into the distal fragment of the radius. The forearm is fixed in neutral position in a plaster-of-Paris circular bandage.

Two cases were thus operated upon by the author with satisfactory results.—*Emanuel Kaplan, M.D., New York, N. Y.*

Volume III, 1931, of the *Orthopaedia i Travmatologia* contains a complete bibliography of the Russian orthopaedic literature for 1928.—*Emanuel Kaplan, M.D., New York, N. Y.*

SO CALLED CALCIFYING SUBACROMIAL BURSITIS. John B. Carnett. *Radiology*, XVII, 505, Sept. 1931.

Codman, who in 1906 first described the condition which he called "Subacromial Bursitis", also was the first to point out that the calcareous deposit occurs not in the bursa but beneath it, in, on, or under the supraspinatous tendon.

The use of the terms subacromial and subdeltoid bursa are misleading. There is one bursa, lying for the most part between the acromion and head of the humerus. A small part extends under the deltoid, but the bursa is properly called the subacromial bursa. Its location makes it inaccessible for complete excision.

Calcareous deposits may occur in or under the supraspinatous tendon, but bear no constant relationship to symptomatology for they may be present without giving symptoms; a mild trauma may precipitate acute symptomatology. Strangely enough, the advent of an acute flare-up of a calcified lesion is often followed by absorption of the lime deposit.

The lesion may be due to an acute traumatic rupture of some of the fibers of the supraspinatous muscle, or to oft-repeated occupational traumata, pinching the tendon between the humeral head and the acromion process, or the acromiocoracoid ligament.

The acute pain at the onset lasts from one to three or four weeks and then may subside completely or persist indefinitely as a dull ache. The more severe the attack, the more likely is the deposit to undergo spontaneous absorption. Symptoms may persist for some months after disappearance of the deposit, and a deposit in a symptomless shoulder may develop characteristic symptoms months or years later. X-rays of both sides in cases of bursitis with unilateral symptomatology show deposits in twenty-five per cent. of the symptomless shoulders. Calcifying bursitis is rare before thirty and usually occurs after forty years of age.

Calcified deposits can be demonstrated only by roentgenograms taken with proper technique,—*viz.*, the central ray directed slightly caudad and laterally, ten degrees from the vertical in each direction. Two exposures are necessary; one with the arm rotated fully outward and one inward. It is easy to mistake these deposits for fractures of the greater tuberosity. Recent deposits are liquid, later becoming caseous and finally gritty. They are always sterile on culture. *Edward N. Reed, M.D., Santa Monica, California.*

UNRECOGNIZED VERTEBRAL FRACTURE *vs.* KUMMELL'S DISEASE (Syndrome). Fredrick W. O'Brien. *Radiology*, XVII, 661, Oct. 1931.

In his original article, in 1891, Kummell called this symptom-complex "rarefying osteitis of the vertebra" and in 1921 "post traumatic disease of the vertebra". Caused always by trauma, it is characterized by severe pain shortly after the accident, which gradually disappears, to appear after months or even years, together with symptoms of peripheral nerve involvement and a definite kyphos and gibbus.

He rules out fractures because of the slight trauma which often produced the condition, and the short duration of the original pain; but admits that a similar condition may result from impacted compression fracture. He believes that a vertebral body is elastic and can be compressed up to a certain point, without demonstrable fracture, and with complete restoration of its original size. This compression, however, does cause a "disorganization of the delicate framework of the bone and produce extravasation of blood in it", which is followed by a gradual disappearance of the bony framework.

Repair in fracture of a vertebral body is notoriously slow; non-union, with absorption and rarefaction, is frequent. This is probably because of the poverty of blood supply to vertebrae.

A wedge-shaped vertebra may occur without trauma,—as an extra segment, a half vertebra, which is wedge-shaped; or as a result of postural fault; or as a result of osteochondritis or epiphysitis (in which condition the base of the wedge may be either anterior or posterior).

The larger part of Kummell's observations were made before the development of satisfactory roentgenograms. With present x-ray technique a compression fracture can usually be demonstrated in these cases immediately following the trauma.

The author believes that the condition described by Kummell is really fracture of the spine,—unrecognized because of the absence of cord symptoms and of inadequate roentgen examination.—*Edward N. Reed, M.D., Santa Monica, California.*

TRAUMATIC LUXATION OF THE COCCYX. Carl S. Oakman. *Radiology*, XVII, 727, Oct. 1931.

There is little medical literature upon the radiographic aspects of fractures and luxations of the coccyx. Its various segments often become fused and, especially after middle age, the first segment may fuse to the sacrum. Variations from the normal curve are common, but apparently have little connection with symptomatology, and the same thing is true of lateral deviations.

Of the cases of luxation reported in the literature practically none include roentgen evidence.

Lateral projections are absolutely necessary in the study of these lesions.

It may be difficult to differentiate between fracture and dislocation.

While at one time there was a fad for excision of the coccyx for painful conditions, the present feeling is that this operation is justified only in certain cases of injury, and in tuberculosis, caries, periostitis, etc.

The most frequent cause of coccygodynia is injury. Fracture and dislocation are probably more common than reports indicate, and minor displacements may result in subsequent synovitis in the sacrococcygeal joint, adhesions, periostitis, periarticular thickening, and irritation of sensory nerves. Lesions after injury have a poor chance to heal because of the difficulty of securing rest.—*Edward N. Reed, M.D., Santa Monica, California.*

Nouvelle Technique pour l'Opération d'Albee dans le Mal de Pott Sous-Occipital. Ath. Contargyris. *Rev. d'Orthopédie,* XVII, 736, Nov. 1930.

The author describes his technique of placing the Albee bone graft in the upper cervical region for tuberculosis. An opening is first made in the occipital bone to receive the upper extremity of the graft, following which the bed of the graft is made by freshening the surface of the tip of the first cervical spinous process, division of the spinous process of the second for a few millimeters, division of the third somewhat more deeply and division of the fourth one centimeter from the tip. Care is taken to preserve the interspinous ligaments. The graft placed in this groove is firmly maintained in place. The author reports a good result by this method, with patient under observation two years after the operation.

Traitement du Pied Bot Varus Équin Congénital Après Deus Ans (Treatment of Congenital Equinovarus Club-foot after Two Years of Age). André Trèves. *Rev. d'Orthopédie,* XVIII, 393, Sept. 1931.

The key to the treatment of congenital equinovarus is the correction of the deformity and the displacement of the astragalus. Its depression in front and the hypertrophy of the luxated portion of the trochlea control the equinus; the inward torsion of the neck and of the head, with the scaphoid placed on its internal border, determines the varus; the obliquity of the under portion of the astragalus aids in the supination.

It is necessary to attack the astragalus in the treatment of remodeling or correcting the ligamentous, tendinous, and osseous obstacles which resist the replacement, both by the position and form. The astragalus should be removed if it is definitely useless.

The different observers are not in accord in regard to the treatment of this deformity; the fundamental difference lies between the purely mechanical and the surgical tendency. The conservative (mechanical) treatment conserves the integrity, and, at the same time, is neither brutal nor dangerous. The operative indications are rare in the young child, and the correction should always be obtained with the minimum of surgery, delayed as late as possible, subcutaneous, and only auxiliary to the manual replacement.

During this period which ends, in general, at about the age of two years—sometimes a little earlier, sometimes a little later—this condition can be regarded as relatively correctable. Finally, the astragalus becomes irreducible and the bones of the external row of the tarsus—the calcaneum and particularly the cuboid—become misshapen and produce the condition of absolute irreducibility, the classic osseous club-foot.

Until seven or eight years of age, the cartilaginous shell of each of the bones of the tarsus is still thin; the club-foot is more cartilaginous than osseous. This is the favorable period for the erosion of the tarsus, which permits modeling of the cartilaginous portion to establish a hypercorrection without injury to the articulations. One should begin by extirpating the center of the astragalus, which may be sufficient, but it may be necessary to remove also a portion of the calcaneum and the cuboid. The erosion should be by open surgery, taking care during the period of replacement and in the remodeling of the foot to lower the trochlear surface of the astragalus to prevent its replacement ultimately in front of the tibia. In addition to this erosion, it may be necessary to excise a portion of the cartilaginous tissue of the external surface of the astragalus.

After the age of seven or eight years, the sacrifice of the bone becomes necessary. When the degree of motion of the tibiotarsal articulation is sufficient, the trochlea of the astragalus can be preserved. Double osteotomy—astragalocalcaneus in the vertical and calcaneo in the horizontal direction—appears to the author preferable to the arthrodeses. Often the astragalus, which is incorrectly articulated with the mortise plate and rigid, should be removed entirely. The calcaneum is replaced perpendicularly between the malleoli, and the calcaneotibial nearthrosis will be more mobile and better adapted to its function than the articulation which it replaces.

With the adult, one does what is necessary—the vertical and horizontal cuneiform resection and section of the plantar aponeurosis—but the osseous sacrifices must be considerably more than with the child. Two points appear definite to the author: the necessity of early treatment and, with the young child, the application of those surgical methods which are benign, and as little mutilating as possible.—*Jacques Calvé, M.D., Berck-Plage, France.*

LES OSTÉOPATHIES HYPERTROPHIANTES. Charles Lasserre. *Rev. d'Orthopédie*, XVIII, 457, Sept. 1931.

The author mentions the difficulty of classification to include under any grouping the proper cases. The pathology and the etiology are not yet thoroughly understood. He bases his classification on the clinical aspect, the progress of the development and the anatomical radiographical appearances of the lesion. He devotes a large part of his paper to a consideration of the "*ostéopathie déformante progressive de Paget*" which, he states, is seen under two forms,—the generalized and the localized. This usually appears as a stationary stage and the disease often exists for twenty years before reaching the terminal stage. There is no evidence to indicate a direct hereditary influence, but rather a predisposition or a favorable soil for the development of this condition. It usually appears about the fiftieth year and the appearances have never been better described than in the original communication of Paget. There is frequently a preliminary painful stage, the conditions progressing by painful recurrences. There is seen then a marked increase in the size and the shape of the bones. Frequently the dilatation of the venous circulation and hyperhidrosis, combined with the symptoms, suggest the possibility that the trophic cerebral medullary centers may be the partial cause. Certain complications have a surgical interest,—such as fractures, etc. Sarcomatous degeneration appears in about five per cent. of the cases and not necessarily in those bones which show the greatest amount of bone change. There are usually three stages which can be distinguished: (1) change of structure; (2) change in form; (3) change in topography.

The histological examination shows that absorption by the osteoblasts is the first phenomenon known. The haversian canals are obliterated and usually the bone structure undergoes an aseptic necrosis. Vascular and cardiac lesions are not infrequent and the thyroid and suprarenal glands may be affected. The acute syphilitic treatment relieves the painful symptoms, but does not affect the development of the lesions. Often actinotherapy has a beneficial effect upon the bone and occasionally on the recalcification.

The paper also stresses "*Les Ostéopathies Hypertrophiantes Craniofaciales*", "*La Périostose Engainante Acromélique*", "*La Mélorhéostose d'André Léri ou Hyperostose en Coulee*".

ZUR BEHANDLUNG ISCHÄMISCHER MUSKELKONTRAKTUREN (Treatment of Ischaemic Muscle Contracture). G. Haberler. *Zentralbl. f. Chir.*, LVIII, 1774, 1931.

From his observations in three cases of ischaemic muscle contracture, the author advocates the following therapeutic measures: Mild cases in the early stages can be cured by application of heat, massage and exercises. Older and more severe cases are to be treated with a turnbuckle apparatus which should be effective in removing all deformity. A primary operative procedure before applying this method must be considered a technical error, as it causes irreparable damage. If the turnbuckle method fails, owing to trophic disturbance, this should be treated by performing a neurolysis. In cases in which all the muscles of one group are completely atrophied and function is lost after correction of deformity, the only available method of treatment is one consisting of tendon lengthening and tendon transplantation.—*R. J. Dittrich, M.D., Wichita, Kansas.*

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The Journal of Bone and Joint Surgery

THE OPERATIVE TREATMENT OF FRACTURED OR DISPLACED SEMILUNAR CARTILAGE

A Comparison of Opinions Concerning the Removal of the Meniscus

FROM THE FOLLOWING SURGEONS:

MARCEL BOPPE, PARIS, FRANCE
J. BRAINE, PARIS, FRANCE
PH. J. ERLACHER, GRAZ, AUSTRIA
R. GALEAZZI, MILAN, ITALY
W. E. GALLIE, TORONTO, CANADA
JULIUS HASS, VIENNA, AUSTRIA
M. S. HENDERSON, ROCHESTER, MINNESOTA
MURK JANSEN, LEIDEN, HOLLAND
ARNOLD JIRÁSEK, PRAGUE, CZECHOSLOVAKIA
SIR ROBERT JONES, LIVERPOOL, ENGLAND
S. KOSTLIVÝ, BRATISLAVA, CZECHOSLOVAKIA
T. P. MCMURRAY, LIVERPOOL, ENGLAND
ALBERT MOUCHET, PARIS, FRANCE
J. PETŘIVALSKÝ, BRNO, CZECHOSLOVAKIA
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V. PUTTI, BOLOGNA, ITALY
WM. O'NEILL SHERMAN, PITTSBURGH, PENNSYLVANIA
FRITZ STEINMANN, BERN, SWITZERLAND
L. TAVERNIER, LYON, FRANCE
H. TURNER, LENINGRAD, U.S.S.R.
ARNOLD WITTEK, GRAZ, AUSTRIA

Attention has recently been called to the wide diversity of opinions and of methods in the treatment of operation of the injured or displaced cartilages of the knee joint, not only in different countries, but also among surgeons in the same country. Particularly is this true with reference to the incision used for exposing the joint for the purpose of removing the cartilage, the amount of cartilage removed, and the length of time of the post-operative treatment. It seemed advisable to assemble a report from men of experience in the different countries and to establish a comparison of the methods used by them. It can be assumed that the principle of conduct established by such men would represent the method which each had found by experience the one of choice because of the satisfactory results

obtained by him. To collect opinions on a few but important points with reference to this subject, statements have been obtained from a number of orthopaedic and general surgeons from different countries, giving their views and their methods of dealing with special features of this subject. The men selected are those surgeons whose opinions and methods would express the representative views in their communities, and all are of an established reputation in their communities. They were asked for a statement of their opinions and of their practice in regard to the following points:

1. Does the severity of the trauma bear any relation to the character and extent of the injury to the meniscus?

2. In its removal, what incision do you consider advisable:
   a. the small lateral?
   b. the large lateral with section of the lateral ligament?
   c. the median patellar?
   d. the lateral patellar?

3. A. Should the whole cartilage be removed or only the injured portion?
   B. With displaced not fractured cartilage, what proportion should be removed?

4. What is the time of postoperative convalescence?
   a. in bed?
   b. before beginning weight-bearing on the leg?
   c. before allowing the full use of the knee?

An attempt has been made to group the answers in tabular form for the ease of comparison, but, in using this method, it has frequently been necessary to indicate the individual's preference in the procedure in question, rather than his definite custom in dealing with these special points. The answers in the table, therefore, cannot be considered as final, for many naturally are given with reservations,—as, for instance, some surgeons indicate their preference for the removal of a portion of the cartilage, but, under certain conditions, practise the extirpation of the entire meniscus. The table is designed for a quick comparison of the points under discussion, and represents the general views and preferences for methods of procedure, modified when advisable by the conditions met with in the individual cases. In the letters accompanying the answers to the four questions, many have expressed views culled from their practical experience; such statements as have definite bearing on the points in question have been taken from the answers and are presented in the pages which follow the table.

It is interesting to observe the wide latitude in the views and the methods of treatment among surgeons, both orthopaedic and general, of recognized skill, judgment, and experience. There seems to be at times something of a national method or point of view. It is hoped that, by this presentation of the various opinions and methods of dealing with this important subject, obtained from representative men of experience in widely separated communities in the different parts of the world, the readers of *The Journal* may find something of profit. *Editor.*

TABLE

Author	Trauma	Incisions Used			Amount of Cartilage Removed		Postoperative Convalescence (in days)		
	Does the severity of the trauma bear a relation to the extent of injury to the cartilage?	*Lateral*	*Is the posterior incision sometimes added?*	*Is suture of the lateral ligament used?*	*Partial*	*Entire*	*How long in bed?*	*How long before first weight-bearing is allowed?*	*How long before full use of knee is allowed?*
M. Boppe	No	Yes		Yes		Yes	10–12	10	21
J. Braine	No	Yes		Yes		Yes	12–15	12–18	18–25
Ph. J. Erlacher	Yes	Yes		No	Yes		14	14	28–42
R. Galeazzi	No	Yes	Yes	No		Yes	10–12	15–25	20–40
W. E. Gallie	No	Yes		No	Yes		14	14	35
Julius Hass	No	Yes		No		Yes	8	8	28
M. S. Henderson	No	Yes	Yes	No		Yes	5	5–7	7
Murk Jansen	Yes	Yes		No	Yes		12	14	21
Arnold Jirásek	No	Yes		Yes (in part)	Yes		12	12	
Robert Jones	Yes	Yes	Yes	No	Yes		7	7	21–35
S. Kostlivý	No	Yes		No		Yes	8	8	21–28
T. P. McMurray	No	Yes		No		Yes	10	10	20
Albert Mouchet	No	Yes		Yes		Yes	12	10	35–42
J. Petřivalský	No	Yes		No	Yes		10–14	28	42–56
John L. Porter	No	Yes		No	Yes		3–4	3	21–28
V. Putti	Yes	Yes				Yes	14	14	30–45
Wm. O'Neill Sherman	No	Yes			Yes		10–14	10–14	21
Fritz Steinmann	No	Yes	Yes	No	Yes		9		28–49
L. Tavernier	No	Yes		Yes		Yes	10	16–18	30
H. Turner	Yes	Yes	No	No	Yes		10	14	35–42
A. Wittek	No	Yes		No		Yes	8	9	

DR. MARCEL BOPPE, PARIS, FRANCE. *Chirurgien des Hôpitaux.*

There is no definite relation between the severity of the trauma and the severity of the injury, but operation is usually found more difficult in those cases in which the patient does not remember the initial injury.

The preoperative diagnosis is important. In cases in which the diagnosis is clear, the lateral incision with suture of the lateral ligament is used. In cases in which the diagnosis is not clear, or, when, with the displaced meniscus, there is hypertrophy of the adipose tissues of the region of the ligament, arthrotomy is performed through the lateral patellar incision. If the diagnosis is not clear between the external or internal cartilage, the transpatellar incision is preferred.

In the bucket-handle injury as complete removal of the meniscus as possible is performed.

DR. J. BRAINE, PARIS, FRANCE. *Chirurgien des Hôpitaux.*

There is no relation between the severity of the trauma and the gravity of the lesions of the cartilage. Usually there is a slight injury, due to the accident, which is completed by the movements of the knee; this explains the sudden appearance of locking.

The small incision is used with the concavity above extending from the tip of the patella to the posterior portion of the condyle. Usually the meniscus is removed *in toto*, in which case it is necessary to cut the lateral ligament, but great care is taken in its repair by careful interrupted suture with non-absorbable thread, linen, silk, or horsehair. If the suture is made with great care, there is no unfortunate result from this section. It is easier to explore the articulation thoroughly and perform a complete meniscectomy by this section which more or less extends posteriorly through the lateral ligament. In case the diagnosis of the position of the lesion is not clear, and if there is a question of further injury—such as injury to the crucial ligament—the transpatellar incision is used.

In general, a complete meniscectomy is practised; but a partial removal is done when it is possible, provided that the portion remaining is entirely uninjured. With displaced, not fractured, cartilage the entire meniscus is removed.

DR. PHILIPP J. ERLACHER, GRAZ, AUSTRIA. *Universitätsprofsssor für Orthopädische Chirurgie, Vorstand der Chirurg.-Orthop. Abteilung der Kinderklinik.*

In some cases there is a distinct relation found between the severity of the joint injury and the injury to the meniscus, yet the luxation of the meniscus can be caused by very slight trauma, particularly when the move-

ment of the leg follows the fixation of the foot. We never operate on the primary, only on the secondary or the recurring cases of derangement.

The inner incision is used, extending as far as the lateral ligament when necessary to expose the joint. If the diagnosis is not clear, or, if in addition to the meniscus injury, there are evidences of injury to the joint, the S-shaped incision of Payr is used in order to obtain a better view of the interior of the joint.

In injuries to the meniscus, either the entire meniscus is removed or only the injured portion, in which case the remaining portion is sutured. It must be remembered that frequently an arthritis deformans may later supervene.

PROF. DR. RICCARDO GALEAZZI, MILAN, ITALY. *Direttore, Pio Istituto dei Rachitici, Clinica Ortopedica e Traumatologica della R. Università.*

The severity of the trauma has no special relation to the degree of injury, but the mechanism of the trauma, which is usually indirect and with torsion, is of more importance.

The lateral incision at the level of the interarticular line is used, but in no case is the lateral ligament severed. When a lesion to the posterior part of the meniscus is suspected, a longitudinal popliteal incision is also used. The median patellar incision is harmful to recovery.

When the meniscus is severely injured, it is removed *in toto*. If there is a partial injury only and a large portion of it is intact, the injured portion only is removed. The displaced meniscus is systematically sutured to the capsule and to the corresponding transverse ligament.

In cases of simple fixation, passive motion is allowed after ten or twelve days, weight-bearing after fifteen days, and full use of the leg after twenty days. In cases of partial removal of the meniscus, the time of remaining in bed is a few days longer. When the meniscus is entirely removed, an orthopaedic apparatus is applied and slight weight-bearing is allowed after twenty-five days with gradual increase. Full use of the knee is allowed only after thirty-five to forty days. The orthopaedic ambulatory apparatus, allowing free joint movement, is worn for two months.

W. E. GALLIE, M.D., F.A.C.S., TORONTO, CANADA. *Professor of Surgery, University of Toronto. Surge n-in-Chief, Toronto General Hospital.*

There is no relation between the severity of the trauma and the character and extent of the injury.

The small incision is used, not more than an inch and a half in length, nearly vertical, between the medial edge of the patella and the most prominent point of the subcutaneous surface of the internal condyle of the

femur, extending downward to the upper border of the tibia. The synovial membrane is opened at the top of the incision, and then split down to the cartilage. Large incisions give no better view than the smaller ones.

Treatment of the meniscus depends upon the condition found on opening. As a rule, the portion of the cartilage displaced or loosened is removed; in bucket-handle tears, when the cartilage is dislocated into the intercondylar notch, the dislocated portion is detached from its two extremities, leaving the narrow rim attached to the capsule undisturbed. In my experience this method results in cure and is preferable, because of its simplicity, to any method that necessitates added operative interference within the joint.

The period of postoperative convalescence varies with individuals. In uncomplicated cases, the patient is kept in bed for two weeks. After two weeks he is allowed up with crutches; slight weight-bearing is permitted. If no effusion results, the weight-bearing is increased. Ordinary walking is usually allowed in five weeks. In older patients, and particularly in those in whom arthritis is present, convalescence is always more prolonged and may occupy several months.

PROF. DR. JULIUS HASS, VIENNA, AUSTRIA. *Vorstand, Universitäts Ambulatorium für Orthopädische Chirurgie in dem Allgemeinen Krankenhaus.*

The severity of the trauma bears no relation to the character and severity of the injury to the meniscus, but, in practically all cases, the sudden rotation of the tibia with the flexed knee causes the injury. Anatomical deformities, such as knock-knee or a constitutional laxity of the ligaments, constitute favorable conditions for the occurrence of this injury.

The parapatellar incision, eight centimeters in length, is used, extending from the edge of the patella, and, if necessary, extended to the S-shaped incision of Payr. The lateral ligament is never incised. The operation is performed with the knee at right angles over the edge of the table.

The displaced or fractured meniscus is completely removed.

The patient is kept in bed eight days with the leg in a plaster cast. The plaster is then removed and the patient is allowed to walk, but the joint is protected by an elastic or rubber bandage for several weeks. The full use of the knee is permitted in four weeks.

MELVIN S. HENDERSON, M.D., F.A.C.S., ROCHESTER, MINNESOTA. *Chief of the Orthopaedic Section of The Mayo Clinic.*

Inasmuch as the trauma is indirect, it is difficult to estimate the actual force acting on the meniscus involved. If the force applied continues to act after the initial tear, there may be irreparable damage to the supportive

ligamentous structures. Therefore, it is fair to say that the severity of the trauma may not bear direct relation to the extent of the injury to the meniscus itself, but does to the future function of the joint. Attention must be given to the fact of the frequency of the damage to the crucial ligaments in cartilage injuries. If there is laxity of the knee joint due to ligamentous injury, considerable disability may follow and prevent participation in athletics. If the patient is not warned of this possibility before the operation, its explanation afterward is somewhat embarrassing.

The anterolateral incision, one and one-half inches in length, directly over the articulation is used with the knee flexed over the table. In case of unusual difficulty in removing the posterior portion of the cartilage, a posterolateral incision in front of the hamstrings is used to remove the posterior portion. Convalescence is not prolonged by the two incisions.

In the majority of cases the entire cartilage is removed, but, if definite injury appears in the anterior portion, the posterior can be left *in situ*. Removal of the anterior three-fifths is usually sufficient, but it should be remembered that a tear in the posterior third or fourth is difficult to see. The displaced cartilage should always be removed.

In the after-treatment the patient may sit up on the second day, but a postoperative splint is worn for five days. The period before weight-bearing is permitted varies with the effusion. With no effusion, the patient is allowed weight-bearing in five to seven days. After a week the patient is allowed to use the knee as much as he wishes, for the anterolateral and posterolateral incisions damage no structures of any importance.

DR. MURK JANSEN, LEIDEN, HOLLAND.

In my experience, failures in the meniscus operations are frequently due to confusion with the nippings of the fat pads, from which differentiation should be made. In estimating the part played by the trauma in the etiology, it must be remembered that the lateral and rotary element is characteristic. The severity of the trauma also plays a part in that the lateral ligament may be torn or distended.

The small lateral incision gives rise to fewer adhesions than the large curved incision. The incisions of Kocher and Payr tend to the formation of more adhesions and are, in my opinion, unnecessarily large for the removal of either the fat pads or the meniscus. The small lateral incision is lengthened only in those cases in which the posterior half of the meniscus is to be removed and cannot be pulled out anteriorly. However, in such cases, the lateral ligament is never severed.

The detached portion of the cartilage should be removed and the other allowed to remain in place if it is firmly held *in situ*, but when there is locking in flexion and tenderness to pressure at the posterior part of the lateral ligament the whole cartilage should be removed.

PROF. DR. ARNOLD JIRÁSEK, PRAGUE, CZECHOSLOVAKIA. *Přednosta I Chirurgické Kliniky, University Karlovy.*

The severity of the trauma does not bear any relation to the character and the extent of the injury, but an intercondylar dislocation is caused by severe trauma. The ligamentous and muscular tonicity plays an important rôle, for in hypotonic patients an insignificant injury may lead to rupture of the meniscus which would not under more normal conditions.

The lateral incision from the inner portion of the ligamentum patellae, extending to the first third of the lateral ligament, is used, but the ligament may be partially severed. The inner parapatellar incision has not proved satisfactory. In the partial, longitudinal rupture, the torn portion of the meniscus is removed; in case of displacement, the whole cartilage is removed.

SIR ROBERT JONES, BART., LIVERPOOL, ENGLAND.

The severity of the trauma undoubtedly bears a relation to the extent of the injury to the meniscus, but a cartilage which has been partially or completely displaced for a long period is more destructive of articular function than a badly fractured cartilage immediately removed.

The cartilage is removed through the small lateral incision, starting an inch from the middle line and passing obliquely downward, crossing the joint about its center. Should there be complications at the posterior part of the cartilage, an additional, almost perpendicular incision should be made in the posterolateral aspect of the joint. The median patellar or the lateral patellar incisions are never necessary. Division of the lateral ligament to any extent is to be scrupulously avoided. The whole cartilage should be removed, with certain exceptions. This can be accomplished usually by displacing the inner cartilage outward and the outer cartilage inward to the center of the joint and by pulling upon the cartilage it can be divided by a short-bladed tenotomy knife. The very short stump left behind is quite harmless. When the anterior end of the cartilage is detached or hanging by a shred and the posterior part is quite firm, the loose piece alone may be removed. If there is the slightest doubt, however, the whole cartilage is best removed.

Weight-bearing may be allowed in two to three days if desired, but usually the patient is kept in bed for a week, with the knee fixed in flexion by a splint. Active movements are allowed in three weeks. From the first, the patient is trained to contract the quadriceps many times a day without flexing the knee. Experience in some thousands of cases has proved that systematic training for sports should not be started for at least five weeks, for, if started too early, a perfect result is often delayed.

It is my custom never to operate in the presence of effusion, nor in old cases do I make a preliminary reduction of the displacement. The rule should be formulated that no knee should be operated upon until symptoms justify the removal of the cartilage. The so called inspection is futile.

PROF. DR. STANISLAV KOSTLIVÝ, BRATISLAVA, CZECHOSLOVAKIA. *Přednosta Chirurgické Kliniky, Komenského University.*

The degree of trauma bears no relation whatever to the extent or shape of the rupture of the cartilage, but the mechanism of the trauma is always associated with a rotary motion and a certain amount of abduction or adduction.

The small, curved, lateral incision is used along the edge of the patella to the level of the joint and curving upward toward the lateral ligament. This ligament is not severed. The total extirpation of the injured meniscus is practised even when it is not fractured.

The patient is not kept in bed more than eight days. If there is then no exudation in the joint, the patient is allowed to walk carefully with a compression bandage. If there is exudation, it is removed by puncture. The patient is allowed to walk freely after three to four weeks, but is advised to wear a knee bandage for a longer time.

T. P. McMURRAY, M.CH., F.R.C.S., LIVERPOOL, ENGLAND. *Honorary Surgeon Northern Hospital, Liverpool, Honorary Surgeon Royal Liverpool Children's Hospital.*

It is my opinion that there is no relation whatever between the type of injury and the injury sustained by the meniscus. It is frequently seen that a man sitting on his heels may, with a very slight twist of his body, make an extensive tear of the whole cartilage, whereas a patient may sustain a very severe injury with a very slight injury to the cartilage. The type of the trauma is more important than the severity.

The preoperative diagnosis is particularly important and, although often difficult, is possible with sufficient care. It is particularly important since in a large group of cases the injury to the cartilage is in the posterior portion and because inspection of such an injury at the time of operation is quite impossible by any incision in the anterolateral aspect of the joint.

The whole cartilage should be removed. If the broken portion only is removed by cutting off its base, the cut fibers are left attached at one end and frequently a further split occurs which results in the failure of the operation. I have operated many times on cases previously operated upon, in which the posterior portion has been left but has subsequently given trouble and required removal. The complete removal of the cartilage can be done through the small anterolateral incision with one exception,—namely, in those rare cases in which the injury is a transverse break at the level of the internal lateral ligament, in which case it is wise to remove the posterior portion at the same time through a small posterolateral incision.

Consideration of the postoperative treatment resolves itself into the question of early movements, which are designed to prevent muscle wasting and stiffness, as opposed to the normal period of rest for any operative wound, during which the scar becomes firm and the traumatic synovitis

caused by the arthrotomy disappears. My practice is to keep the patient recumbent for ten days, with the knee slightly flexed on a splint, before removal of the stitches, followed by ambulatory treatment with fixation for another ten days and then free use of the knee. In no case have I found any trouble with restriction of movements or any difficulty in restoring the muscles to their normal tone.

DR. ALBERT MOUCHET, PARIS, FRANCE. *Chirurgien de l'Hôpital St.-Louis, Ancien Président de la Société Française d'Orthopédie.*

I have not observed that the severity of the trauma influences clearly the form or extent of the injury to the meniscus, but repeated injuries exert a definite influence.

The incision used is the internal transverse, with section of the lateral ligament if necessary. The ligament is repaired by interrupted stitches of horsehair and does not give any unfortunate results.

The meniscus is removed *in toto*, whether it be fractured or displaced. However, in the meniscus bipartitus the internal, free portion only is removed, leaving the outer peripheral portion adherent to the capsule.

In the after-treatment the patient is kept in bed for twelve days, and then is allowed to be up only with crutches, and is given massage and exercises to develop flexion in the knee. Mobilization, however, is always active, never passive.

PROF. DR. JULIUS PETŘIVALSKÝ, BRNO, CZECHOSLOVAKIA. *Přednosta Chirurgické Kliniky, Masarykovy University.*

In indirect injury to the meniscus, the force of external rotation and abduction of the tibia plays more of a part than the severity of the trauma. Direct injury to the meniscus is rare, but in direct injury the trauma bears a definite relation to the character and extent of the injury.

The short, transverse, curved incision from the attachment of the ligamentum patellae to the edge of the lateral ligament is used, but the ligament is never cut. In cases requiring a larger entrance and a more complete view, the incision is extended upward to the inner parapatellar area. In cases of partial break or partial dislocation, only the injured portion is removed. In cases of total rupture, the whole cartilage is removed.

JOHN L. PORTER, M.D., F.A.C.S., EVANSTON, ILLINOIS.

The positive diagnosis as well as prognosis is unwarranted in almost any case, for there is no other operation in orthopaedic surgery in which such startling surprises often await the operator. Removal of the cartilage,

or as much as can be removed without unnecessarily long incisions or too great exposure of the joint, gives the most satisfactory results. The anterior portion of the meniscus can be removed, leaving the posterior fourth, with complete recovery of function. The three-inch curved incision is adequate for the removal of the cartilage and the inspection of the crucial ligaments, and does not injure the lateral ligament. Removal of the entire cartilage is more desirable, but there are cases in which it is difficult. It is better to leave a portion than to spend too much time or to make too large an incision in exposing the joint.

In the after-treatment a plaster cast, or a posterior splint, is applied and worn for two days, when it is removed and the knee gently flexed. This is repeated on the third day and the patient is allowed to get out of bed and bear weight on the foot. The splint is worn for a week, but removed each day for passive movement, which is very gradually increased. The patient remains in the hospital, but not in bed, for about eight days until the stitches are removed, after which a knee cage is applied. The patient is allowed to use the leg as much as is possible with this protection and massage is begun. The full use of the leg with normal function is not possible until the capsule is fully healed and the exudate has subsided, which takes from three to four weeks.

PROF. DR. VITTORIO PUTTI, BOLOGNA, ITALY. *Direttore, Istituto Ortopedico Rizzoli, Clinica Ortopedica della R. Università.*

There is a relation between the severity of the trauma and the type of injury, but clinically it is very difficult, if not impossible, to establish this relation.

The inner incision, ten centimeters long, is used with section of the lateral ligament if necessary. The entire cartilage is removed, even if it is only displaced and not torn.

In the after-treatment a splint is worn for fifteen or twenty days, after which the patient is allowed mobilization. A splint is advised during the day for a month to six weeks after the operation.

WM. O'NEILL SHERMAN, M.D., F.A.C.S., PITTSBURGH, PENNSYLVANIA. *Chief Surgeon of the Carnegie Steel Company.*

The severity of the trauma does not necessarily bear any relation to the extent of the injury to the meniscus, but trauma beyond a certain point involves the associated structures of the knee joint, making the meniscus a secondary consideration.

As much as possible of the injured cartilage is removed, but with displaced and not fractured cartilage the entire meniscus should be excised.

DR. FRITZ STEINMANN, BERN, SWITZERLAND. *Professor der Unfallmedizin an der Medizinischen Fakultät; Chefchirurg am Städtischen Spital und am Engeriedspital.*

The severity of the trauma bears no direct relation to the character or the amount of the injury to the meniscus. Because of the peculiar mechanical construction of the knee and the direction of the forces which are applied to it, the mechanics of the dislocation are particularly important. The position of flexion of the knee plays an important rôle in determining the occurrence of, as well as the character and extent of, the injury to the cartilage.

The lateral incision is used, which gives a sufficient view of the cartilage in the ordinary case. If necessary, the incision can be extended forward according to the method of Payr, or it may be extended backward to the lateral ligament, which is not cut. When necessary, a posterior incision may also be made.

As much of the cartilage is taken as is movable in order to insure against further impingement on the portion that remains. In the case of cartilage fractured from before backward, and which clinically shows blocking, as well as in the meniscus bipartitus, the whole cartilage should be removed.

In the early operations the length of time which the patient remains in bed averaged nine and two-tenths days and in the hospital eighteen and four-tenths days. Later, with the improvement in technique, the average stay in the hospital was shortened to thirteen days. In the early cases the patients were able to return to their work in an average of seven and nine-tenths weeks. It is interesting that in twenty-six of the cases not insured the average time was four and one-tenth weeks; in fourteen of those individually insured, six and one-tenth weeks; and in fifty-six of those benefiting from compulsory insurance, ten and one-tenth weeks.

DR. L. TAVERNIER, LYON, FRANCE. *Professeur Agrégé à La Faculté, Chirurgien de l'Hotel-Dieu.*

There is no relation between the severity of the trauma and the severity of the lesion of the cartilage, but frequently an extensive longitudinal tear of the cartilage is seen after a simple injury.

The meniscus is removed by a large transverse incision, with section of the lateral ligament. This section of the ligament gives no later inconvenience, provided the suture is thorough and it is replaced without stretching. This opening is necessary for a complete exploration and complete removal of the cartilage, although section of the lateral ligament prolongs the convalescence.

The entire cartilage is removed, whether it is torn or simply loose.

The patient is kept in plaster ten days. Weight-bearing is not allowed before sixteen to eighteen days. Active use of the knee is allowed at the end of a month and full use of the knee for sports after three months.

DR. HENRY TURNER, LENINGRAD, U.S.S.R. *Professor in Medical Military Academy.*

It does not appear to be necessary to remove the whole cartilage, the posterior part not being subject to the pressure due to the extension of the knee. Our operations are becoming more and more conservative and restricted to the removal of the protruding tabs. Rupture of the anterior portion, with deformity and cicatricial distortion of the cartilage, are positive indications for total excision. Fixing the cartilage by sutures in cases of circumscribed tears may be a reasonable, economic procedure, the efficacy of which we have not yet had opportunity of fully proving.

A small, curved, lateral incision is generally used, with the knee flexed over the edge of the table. Neither the section of the ligament nor the posterior incision is used.

The patient is kept in bed ten days, after which the sutures are removed and light massage is given. In two weeks after the operation, the patient is allowed the use of the leg for walking, flexion being restricted by a light splint. During the following week, passive exercise of the knee and massage of the whole limb are given, and the patient is allowed the full use of the limb in five to six weeks.

PROF. DR. ARNOLD WITTEK, GRAZ, AUSTRIA. *Vorstand des Orthopädischen Spitales und Unfall-Krankenhauses.*

There is no relation between the severity of the trauma and the character of the injury to the meniscus, but it is recognized that by repeated and extended trauma a severe injury may occur, in which case there are frequently other injuries accompanying it,—as, for instance, injury to the crucial ligaments.

The entire cartilage is always removed. In its removal the median curved incision of Payr is used. This permits a thorough inspection of the joint which is extremely necessary in order to insure the detection of further injury.

Rest in bed with the knee in a splint is advised for eight days. After the ninth day the sutures are removed, protection is given with an elastic bandage, and full weight-bearing is allowed.

STREPTOCOCCUS VIRIDANS OSTEOMYELITIS

BY EDWARD L. COMPERE, M.D., CHICAGO, ILLINOIS

Department of Surgery, Division of Orthopaedic Surgery
University of Chicago Medical School

Pathologists and clinicians who are pathologically minded have long debated the question of the etiology of the solitary bone cyst, benign giant-cell tumor, and osteitis fibrosa and their relation to malignancy. Schlange[1] was probably the first to call attention to the similarity between the microscopic changes in the fleshy lining of a bone cyst and those noted in known cases of low-grade osteomyelitis and his conclusions were supported by the studies of Tietze[2] and Bischoff[3], while Mallory[4] and Bloodgood[5] agreed that the changes in the cyst wall are those of chronic inflammation. The clinical and roentgenological similarity between the benign giant-cell tumor and the solitary bone cyst is well recognized, and in some instances a microscopic examination of the tissues does not clearly differentiate the lesions.

While both conditions have been studied in detail by the pathologist, few reports of attempts to culture organisms from either type of lesion have been made. In 1926 Phemister and Gordon[6] reported two cases in which streptococcus viridans was isolated in each instance from a solitary bone cyst. At the same time they stated that benign giant-cell tumor "has often been regarded as a chronic inflammation, but as yet there is no bacteriological evidence to substantiate the view". Phemister[7] reported in 1929 that he was unable to find in the literature an authentic case of osteomyelitis due either to the anhemolytic streptococcus or to streptococcus viridans. During the last two years Day[8] has found the streptococcus viridans in cultures of two additional bone cysts operated on in University of Chicago Clinics, while in eight other cases studied no bacterial growth was obtained. These negative findings cast doubt on the etiological rôle of streptococcus viridans in solitary bone cyst.

The report of Mandl[9] that improvement in a case of generalized osteitis fibrosa followed removal of a parathyroid tumor has been confirmed by investigators in Germany, England, and America; and hyperparathyroidism[10] is now thought to be the etiological factor in some cases of osteomalacia and similar conditions associated with generalized osteoporosis. But there is little evidence to indicate—and it would be difficult to rationalize the finding if it were so reported—that localized bone lesions of the bone cyst and giant-cell tumor type, without any general skeletal involvement, could be explained on a metabolic basis.

Trauma is the ever present etiological goat to which is tied the blame for many pathological conditions by the patients themselves and, in some instances, by the physicians attending them. Evans[11] has pointed out that there are probably three types of changes classified under the general heading of osteitis fibrosa: those due primarily or entirely to systemic disturbances of calcium metabolism, which he believes are the polycystic lesions (this is the multiple fibrocystic disease with hyperparathyroidism); the solitary bone cysts which he considers primarily of infectious origin, but often associated with trauma; and osteitis fibrosa without cyst formation, which is probably of infectious origin, but may also be associated with trauma and dependent upon local metabolic factors as yet undetermined.

Pommer[12], Konjetzny[13], and Looser[14] have supported the view, more recently subscribed to by Geschickter and Copeland, that the so called "brown tumors" are a result of hemorrhage into the marrow, and the absorption of the hemorrhagic deposits by the giant cells leaves the typical bone cyst. The hematoma theory does not offer an adequate explanation of solitary bone cyst. It would be absurd to try to account, on that ground, for the new bone formation in the second case reported in this paper.

Geschickter and Copeland[15], in an analysis of over 400 cases of tumors in the giant-cell group, claimed a pathological relationship between the bone cyst, giant-cell tumor of the long bones and skull, giant-cell epulis of the alveolar borders, and giant-cell tumors of the tendon sheaths. These authors further believe that "the average solitary bone cyst in the long bones is a healed or healing giant-cell tumor". They also suggest that the average giant-cell tumor shows a healing change toward osteitis fibrosa. As a result of these studies they conclude that the etiological factor necessary to the production of a giant-cell tumor is a disturbance of the vascular supply to these regions following trauma, and that giant-cell tumors are histogenetically neoplastic and not inflammatory. No mention was made of attempts to culture bacteria from the lesions studied.

Eliason and North[16] agree with the views of Geschickter and Copeland and include fibrous osteomyelitis in the group of diseases classified as osteitis fibrosa. They express the belief that the etiological factor is trauma and criticize the infectious theory of origin of the bone lesions in this group on the ground that the histological picture "is not that of an infiltrative reaction to bacterial invasion", and the "symptomatology is not that of an infection". No bacteriological studies were reported in their series.

Garland[17] felt that trauma was a definite factor in production of the bone lesions. In his brief report of cases, no mention is made of bacteriological studies.

A survey of the literature reveals no mention of any careful study, with satisfactory bacteriological technique, of material removed from benign giant-cell tumors.

In the following cases two cultures of each lesion were made on blood agar plate, ascitic broth, and Rosenow's brain medium. As in some of the

cases of bone cyst cultured in this Clinic, the plates were negative; but in the two tubes of Rosenow's brain medium in Case 1 there was a growth of cocci well below the surface. On subcultures of blood agar plates these grew with a green pigment formation and were slightly hemolytic. A microscopic study revealed chain-forming cocci. No report of the successful culture of an organism from a benign giant-cell tumor has been found in the literature. In a large series of control cultures[18], made from apparently normal tissues removed in the same operating room and cultured under similar conditions, streptococcus viridans was cultured only once and that from an old fracture at the hip upon which a Whitman reconstruction operation was performed.

CASE REPORTS

Case 1. The patient, a white male, aged thirteen, came to the University of Chicago Clinics July 2, 1930, complaining of pain in the dorsum of the right foot. Ten months previous to this admission to the Clinics he had jumped in such a way as to strike on the right foot with considerable force. He experienced a sharp pain in the region of the right lateral malleolus. The pain lasted about fifteen minutes and during that time he was unable to walk, although he later managed to walk to his home, a distance of about one-half mile. The ankle was swollen for a day and a dull aching pain, present upon inversion of the foot and when walking, had persisted to the date of admission. Since January the pain had been more marked in the morning, associated with a feeling of stiffness in the ankle and a definite limp upon walking, but the disability

Fig. 1-A

Case 1. Roentgenogram showing a destructive lesion (*a*) in the neck of the astragalus. The anterior cortex of the bone has been pushed up and broken through.

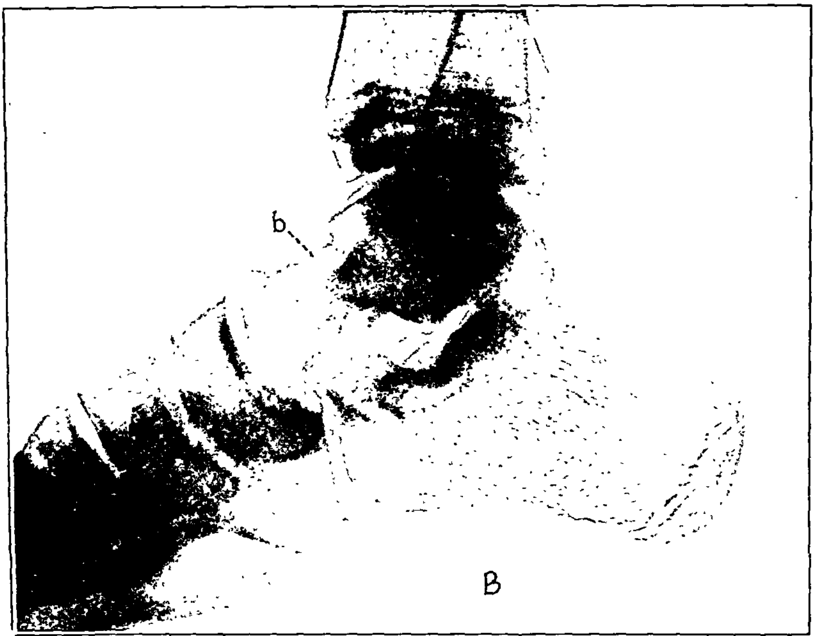

Fig. 1-B

Case 1. Showing the defect (*b*) in the bone three days after removal of the tumor tissue. (There is a faint line of bone density which forms an irregular arch over the defect suggesting that the cavity had filled with blood and thus distended the periosteum with small fragments of bone attached to it.)

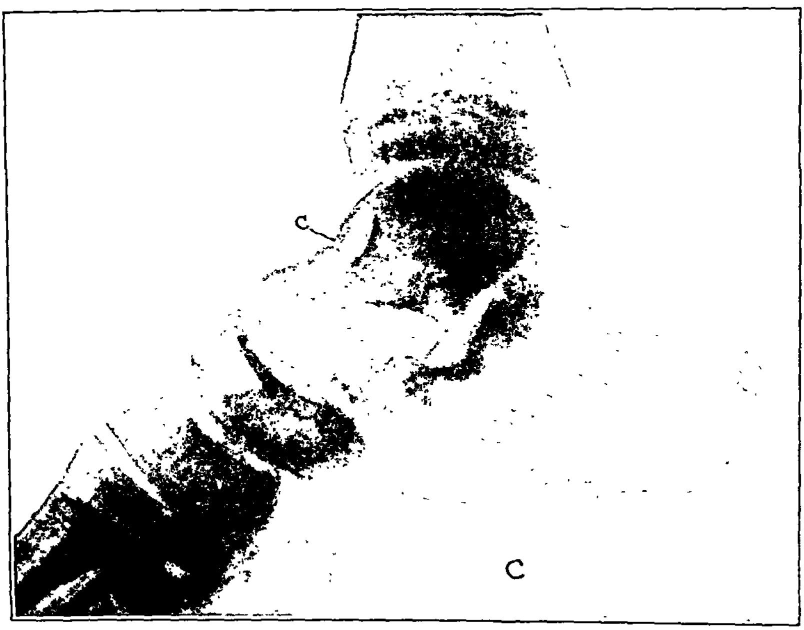

Fig. 1-C

Case 1. Six months after operation the defect (*c*) has been almost completely replaced by bone of relatively normal density.

FIG. 2-A

FIG. 2-A

Case 1. This illustrates the portion of the tumor in which fibrous tissue (*a*) has replaced the normal fatty marrow. The bone spicules (*b*) are undergoing absorptive changes where the fibroblasts are in contact. This is especially marked in the lower corner of the field where the bone spicule is almost completely surrounded by a row of fibroblasts with large and pyknotic nuclei. A moderately dense infiltration of lymphocytes (*c*) is noted in one portion of the field. (× 100.)

FIG. 2-B

Case 1. In this area taken from the same section the fibroblasts (*b*) are more compactly arranged and in some regions there is a tendency toward palisade formation. A number of large giant cells (*a*) with centrally placed nuclei are also noted. (×100.)

FIG. 2-B

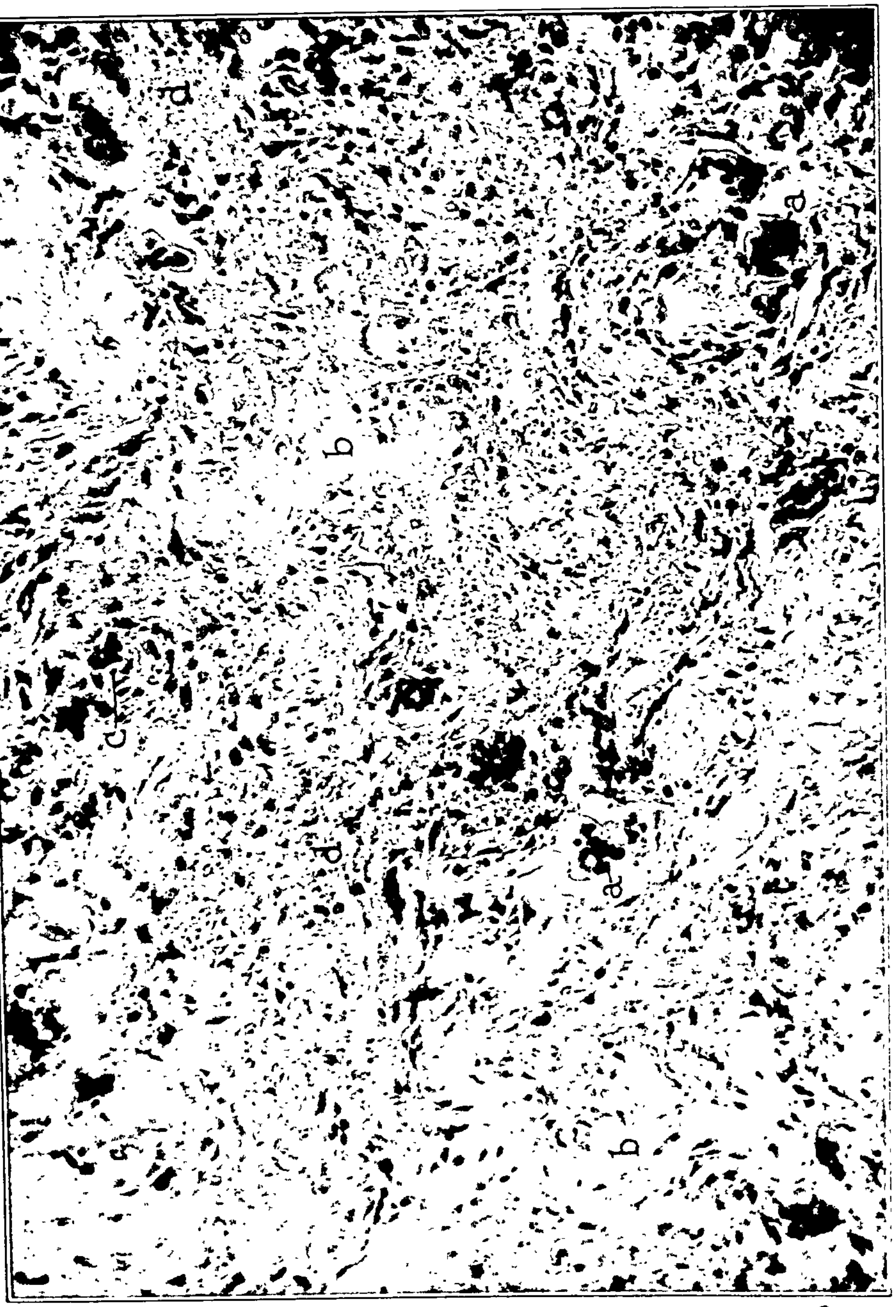

Fig. 3

Case 1. The multinucleated giant cells (a), the osteoid tissue (b), the fibroblasts (c) with their large nuclei, and the rather extensive areas of recent hemorrhage (d) are well illustrated in this section. ($\times$ 225.)

became less during the day. During February the discomfort was more marked, but as the weather became warmer it diminished. At the time of admission the patient stated that the pain in the ankle was alleviated by exercise without weight-bearing, rest, massage, heat applied locally, or by warm weather. The pain was aggravated by weight-bearing, particularly as the weight was shifted to the ball of the foot in taking a step or upon shifting the weight to the lateral and volar portion of the foot. Pain was also more marked when the weather was cold.

The family history and the past medical and surgical history of the patient were not relevant.

An examination of the foot revealed slight swelling, tenderness, and definite increase in heat localized to the dorsum of the foot in line with the ankle joint. There was no swelling, tenderness, or increase in local heat posteriorly or about the malleoli. Attempts to completely extend or dorsiflex the foot produced pain over the astragalus anteriorly.

The x-ray examination revealed a lesion in the neck of the astragalus just posterior to its articulation with the scaphoid bone (Fig. 1-A). This consisted of an area of reduced density two centimeters in diameter which was bordered anteriorly by a thin shadow of bony density which bulged upward and was broken through in a small area. It was regarded as either chronic pyogenic infection or tuberculosis. The clinical symptoms and findings favored the former.

The patient was admitted to the hospital July 9, 1931. The temperature on admission was 100.4 degrees, and it was 99.2 degrees on the following morning before operation. The urinalysis was normal, hemoglobin eighty per cent., red cells 4,510,000, and white cells 7,900 per cubic millimeter. Wassermann and Kahn tests were negative.

At operation July 10, 1930, the cortex of the bone was found to be elevated, and reddish tissue bulged through in a small area. A curet was inserted and reddish-brown, spongy tissue was removed, leaving a cavity about two centimeters in diameter (Fig. 1-B). The cavity was sponged with iodin and alcohol and dried. Closure was made without drainage and a cast was applied.

Using the bacteriological technique previously described, a chain-forming, green-producing streptococcus was isolated by Lois Day from a culture of some of the "tumor" tissue. Guinea pigs inoculated with some of the material remained negative for tuberculosis.

A microscopic section stained with hemotoxylin and eosin was found to be composed chiefly of fibrous tissue with many immature fibroblasts, anastomosing spicules of osteoid tissue, bone, and numerous giant cells with centrally placed nuclei (Figs. 2-A, 2-B, and 3). Many of the giant cells were found to lie in Howship's lacunae and adjacent bone fragments were undergoing resorption from those osteoclasts of Kölliker. Most of the tissue was quite vascular and the arteries showed marked internal thickening. Fat, containing bone marrow, was noted in the section adjacent to the wall of the cavity. In some small areas periarterial round-cell infiltration was noted with a number of polymorphonuclear leucocytes and numerous red blood cells which suggested recent hemorrhage. A few histiocytes contained brown blood pigment, though no pigmentation was noted in the giant cells themselves. Sections examined* with Maximow's connective-tissue stain clearly differentiated the red blood cells and demonstrated finely granular calcium in the osteoid tissue. With Heidenhain-Mallory stain the osteoid tissue* was found to consist of a network of collagenic (blue-staining) fibers with streaks of red, denoting beginning ossification.

The fibroblastic and giant-cell reaction resembled that of fibrous osteitis and benign giant-cell tumor. However these reactions are not inconsistent with inflammation and numbers of infiltrative cells were present which, with the clinical history and the bacteriological findings, justified a diagnosis of streptococcus viridans osteomyelitis.

*Prepared and studied by Dr. P. A. Delaney of the Department of Pathology.

The patient had a low fever for four days following operation but made an uneventful recovery and there was no discharge from the wound. When seen in the clinic December 29, 1930, less than six months after operation, he was able to walk without any pain and without a limp. There was no tenderness, increase in local heat, or swelling, and the range of ankle-joint motion was normal. An x-ray at that visit showed that the site of the old lesion in the right talus had been filled in with new bone. There has been no recurrence and the foot is now, fifteen months after operation, functionally entirely normal.

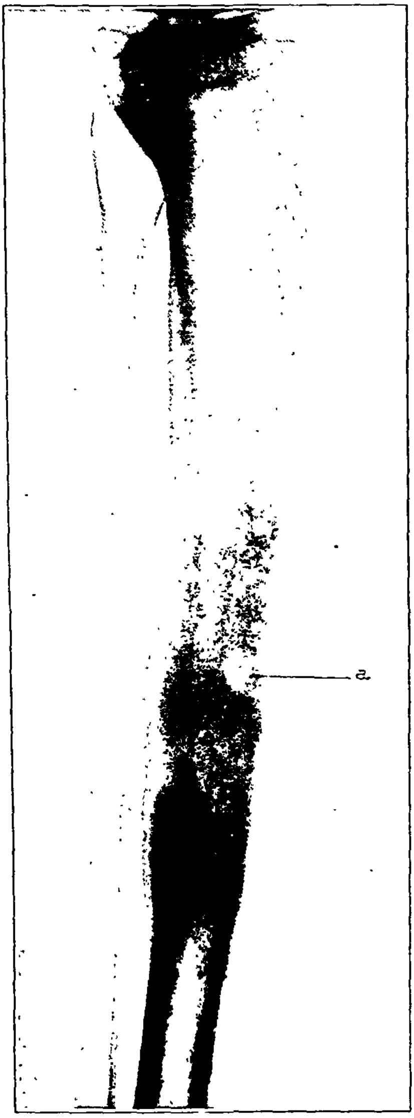

Fig. 4

Case 2. Roentgenogram showing the fusiform swelling of the left tibia with a small cavity (a) which appears to be in the mid-portion of the medullary canal.

Fig. 5

Case 2. The thick involucrum has been removed and the cavity noted above is no longer present.

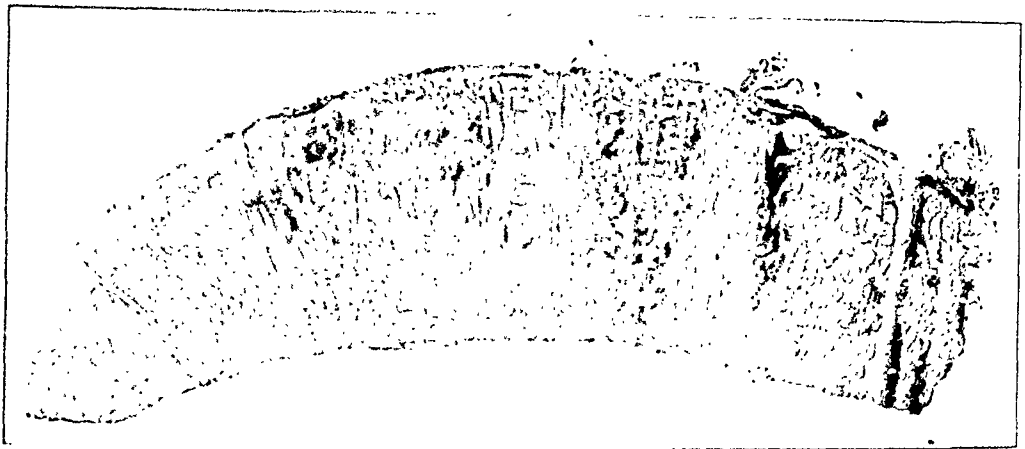

FIG. 6
Case 2. Cross section (× 4) of the hyperplastic involucrum, the density of which approaches that of cortical bone.

The similarity between the microscopic picture of benign giant-cell tumor and the tissue occupying the region of bone destruction in certain cases of fibrous osteomyelitis is demonstrated in the following report.

CASE 2. A white female school teacher, aged thirty-two, entered the University of Chicago Clinics, March 11, 1931, complaining of pain and swelling of the left leg. In September, 1930, five months previous to this admission, the left tibia was struck against the edge of a chair, causing severe pain which lasted for a few minutes only. The incident was forgotten, as no soreness or pain persisted at the site of injury, until October, one month later, when a small lump or swollen area was noted over the anterior margin of the middle of the left tibia. This swollen nodule steadily increased in size and became painful and tender to pressure.

At the time of admission, pain was described as a dull ache, worse at night or after walking, and at times seeming to involve both the knee and the ankle.

The patient denied any recent cutaneous lesion, although she recalled a furuncle of the lip two years previously. She had had a brief attack of pain in both hips ten years before this admission.

Examination of the left leg revealed a hard fusiform swelling over the anterior portion of the upper and middle third of the tibia, with moderate tenderness upon pressure over the mid-portion of the tumor. No redness of the overlying skin could be determined and increase in local heat could not be definitely established. Reflexes were present and equal on the two sides and the other bones and joints seemed to be normal. The clinical impression was osteomyelitis, Ewing's sarcoma, or syphilis.

X-rays showed that the fusiform swelling was dense bone about the tibia and thickest laterally. In the central portion of this mass, an area of reduced density in the lateral cortex one centimeter in diameter was noted (Fig. 4).

The blood Wassermann and Kahn tests were negative, white cell count was 8,500, red cell count 4,460,000, and hemoglobin eighty-five per cent. Urinalysis was normal.

A diagnosis of chronic localized osteomyelitis with a central area of cortical destruction and very marked surrounding new bone formation was made and on March 23, 1931, an operation was performed at which the thick peripheral layer of new bone was removed anteriorly and laterally, uncovering a cavity one centimeter in diameter (Fig. 5). Half of its wall was formed by the old lateral cortex and half by the new involucrum and it was filled with firm dark red granulation tissue.The cavity in the old cortex was scraped out and the wound closed with drainage.

Fig. 7

Case 2. A higher magnification of the section of new bone shows the fibrous marrow (*b*) filling the narrow cancellous spaces. The borders of the thick bone trabeculae (*a*) are lined with fibroblasts (*c*) which seem to be aiding in the formation of new bone (× 65.)

There was slight serosanguineous discharge for five or six days following operation, but the wound healed and the patient left the hospital on the eighth day. On May 9, 1931, six weeks after the operation, she had no pain or discomfort in the left leg and there was no tenderness and no swelling, and the x-rays revealed no recurrence of the lesion.

Duplicate cultures of the lesion were made in Rosenow's brain medium, ascitic broth, and blood agar plates. Sarcina lutea were grown in one tube of Rosenow's media and staphylococcus albus in one ascitic broth culture. But since the other cultures were negative, these were thought to be contaminations.

The specimen removed at operation consisted of five large pieces of bone of cortical density. The largest piece (Fig. 6) was spindle-shaped and measured twelve by two and five-tenths centimeters in greatest diameter, by three-tenths of a centimeter in thickness, and contained half of the wall of the cavity previously noted.

Microscopic studies of the bony involucrum revealed dense hyperplastic bone with thick trabeculae containing well defined haversian canals. The narrow cancellous spaces contained largely fibrous marrow (Fig. 7).

A section at the junction of bony involucrum and the soft tissue filling the cavity showed active absorption of bone by a layer of cells consisting largely of fibroblasts and Kölliker's giant cells. This fibroblastic absorptive tissue did not invade the cancellous spaces.

The tissue from the small central cavity consisted of a mixture of osteoid tissue, numerous giant cells, and bands of connective tissue. The stroma was hemorrhagic and the osteoid tissue was quite cellular, incorporating many fairly large cells in its matrix, and along the periphery there was a layer of osteoblastic cells, as well as numerous lacunar spaces in which were osteoclastic giant cells. These cells possessed a large nucleus and abundant cytoplasm in which an occasional vacuole was noted (Fig. 8).

From a second region a section of tissue stained with hematoxylin and eosin was strikingly cellular. The numerous cells were of large mononuclear and multinuclear types, in places arranged about relatively small trabeculae of osteoid tissue. In the intertrabecular stroma there were many free cells—round, oval, or elongated—with a nucleus that was round to oval and generally with a moderate amount of chromatin. No evidence of mitosis was seen in either cell type. Capillaries were fairly numerous and calcified areas were rare, although many of the osteoid trabeculae showed a meager diffuse deposit of calcium and some were definitely ossified.

COMMENT

The growth of streptococcus viridans in cultures of a bone lesion which was microscopically similar to some cases of localized osteitis fibrosa and of benign giant-cell tumor is the first bacteriological evidence submitted in support of the theory that some of these lesions may be low-grade infections.

It is most probable that the reason for the dearth of information concerning the incidence of streptococcus viridans infections in bones is due, not so much to any extreme rareness of the disease, but to the failure of physicians to apply the technique elaborated for the investigation of streptococcus infections of the soft parts to infections of bone. Using the technique employed by Rosenow for isolation of such organisms, Phemister, Brunschwig, and Day[18] succeeded in culturing streptococcus viridans in two cases of Kienböck's malacia and one each of Köhler's disease, Legg-Perthes-Calvé's disease, and osteitis deformans.

The pathological changes produced by streptococcus viridans infections of soft parts—such as have been reported by Rosenow[19], Birkhaug[20],

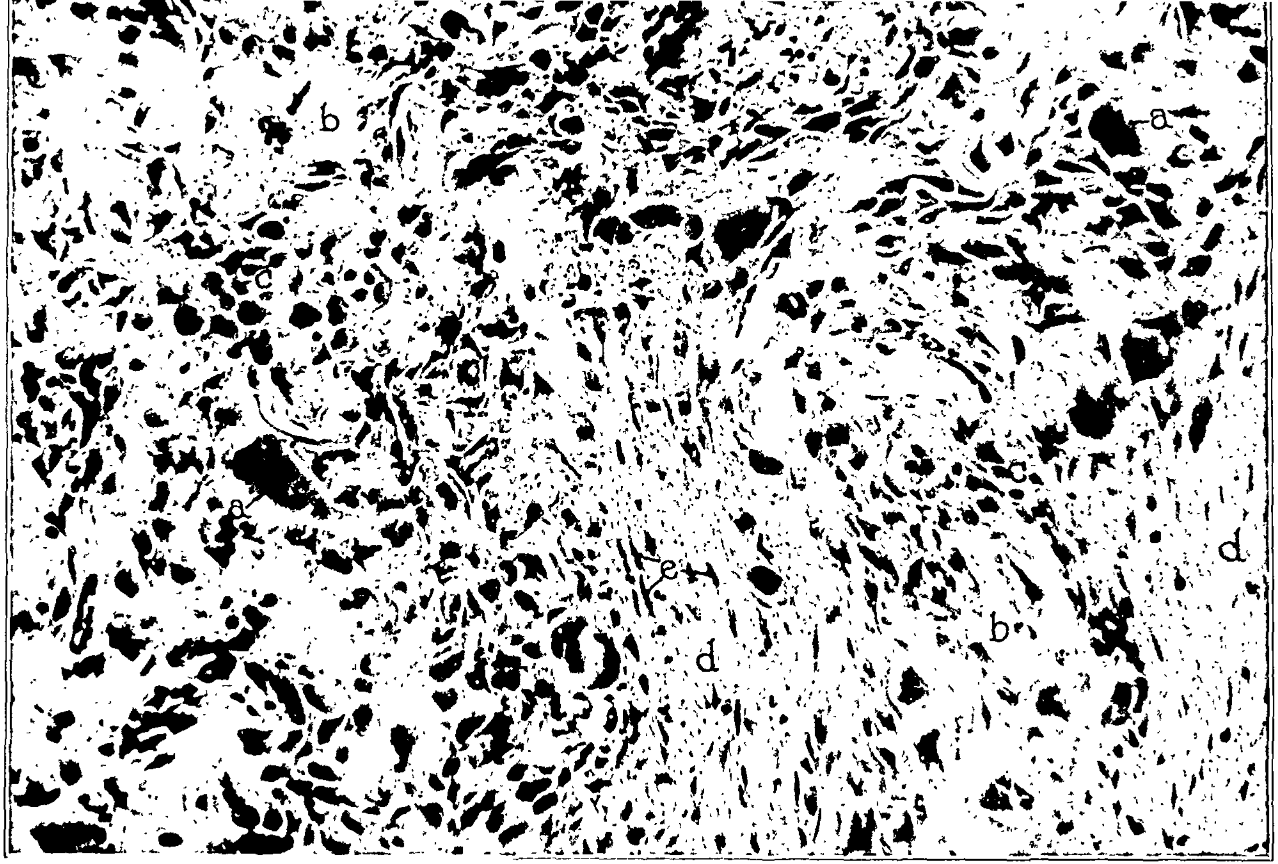

FIG. 8

Case 2. Section of soft tissue filling cavity (*a*) in Fig. 4. The fibroblastic granulation tissue (*c*) is infiltrated with foreign-body type of giant cells (*a*). There are many areas of osteoid tissue (*b*) and several areas of hemorrhage (*d*), but very little pigmentation. No leucocytic infiltration is present. Note parallel arrangement of fibroblasts in the areas of hemorrhage. (× 225.)

Swift[21], Small[22], and Billings, Coleman, and Hibbs[23], in arthritis, encephalitis, rheumatic fever, and particularly in subacute bacterial endocarditis—are fairly definitely established. In certain stages these show many polyblasts and giant cells with many centrally placed nuclei in greater numbers than are seen in infections produced by the other pyogenic organisms and yet quite typical of the pathological findings in many cases of localized osteitis fibrosa or solitary bone cysts. Frank pus is rarely observed in the above group of diseases, although their infectious origin is generally admitted.

Phemister[24] has described a clinical syndrome in which osteomyelitis pursues a chronic course from the onset, developing as a circumscribed area of bone broken down largely by fibroblastic activity and the space filled up with soft tissue. In the group of cases which he reported, some of the clinical histories and the histogenetic pictures were similar to those included in this paper. With the exception of a growth of staphylococcus aureus from one lesion, thought to be contamination, no positive cultures were obtained in his series of cases. Phemister discussed the contentions of Konjetzny[13] and of Looser[14] that these so called brown tumors of bone were the result of hemorrhage that sets up an active absorption process within the bone, and that of Axhausen[25] that they were the result of anaemic infarcts and merely a process of aseptic necrosis. But he expressed the opinion that these lesions could be better explained on a basis of infection by organisms of low virulence, belonging to the pyogenic group, but not setting up the usual cytological reaction of acute pyogenic inflammation.

Since Phemister and Gordon[6] and Phemister, Brunschwig, and Day[18] have found streptococcus viridans in cultures of the lining wall of four cases of solitary bone cyst, the culture of the same organism in this case adds an etiological link to the evidence that the two similar pathological conditions may perhaps be different stages of the same process. Phemister and Gordon suggested this when they stated that "cases are seen in late adolescence or early adult life, in which it is difficult to say whether the lesion should be classified as bone cyst with a thick fleshy lining or benign giant-cell tumor which has undergone cystic degeneration". While the lesion described in neither of these two cases is typically that of the true benign giant-cell tumor, the microscopic picture is similar to that seen in lesions classified in the osteitis fibrosa group.

In both of the cases which are included in this report there is a fairly definite history of trauma as an etiological factor. Clinically both lesions were inflammatory in nature and, in Case 1, the patient had a slight febrile reaction and a pure growth of streptococcus viridans was cultured from the lesion. But the microscopic picture of the tissue filling the region of bone destruction in the two lesions was similar to that which Geschickter and Copeland have described in their cases of osteitis fibrosa and which they conclude cannot be inflammatory in nature because there is so little leucocytic invasion.

While no conclusions can be drawn from a single case, the finding of streptococcus viridans in cultures of this lesion justifies greater bacteriological interest in the study of similar lesions in the future.

SUMMARY

1. The etiology of osteitis that is characterized by a fibroblast and giant-cell proliferation with bone destruction and new bone formation has been discussed.

2. A case was reported in which a strain of green-producing streptococcus grew in cultures of a lesion in the neck of the astragalus, which presented a microscopic picture similar to that of localized osteitis fibrosa without cyst formation. Clinically and bacteriologically it was a low-grade pyogenic infection and has been classed as streptococcus viridans osteomyelitis.

3. A second case, which was clinically and pathologically similar to the first, except for bone proliferation, but in which the cultures were negative, was also reported.

4. That trauma may be a factor in localizing the infection is again suggested by these cases, but the opinion is expressed that reaction to trauma and hemorrhage could not alone account for the cortical absorption and the extensive new bone formation noted in Case 2.

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TROCHANTERIC TRANSPLANTATION IN THE TREATMENT OF FRACTURES OF THE NECK OF THE FEMUR

BY ELLIS JONES, M.D., LOS ANGELES, CALIFORNIA

The writer presents the following method of operative attack to be used in selected cases of fractures of the neck of the femur, believing that methods of closed reduction fail in a large proportion of cases. This method is employed in the treatment of patients with fresh fractures as well as in cases showing delayed or faulty union.

OPERATIVE TECHNIQUE

With the patient lying on the sound side on a fracture table and with the injured leg under the control of an assistant, a six-inch, straight, external Langenbeck incision is made, extending from the iliac crest downward over the trochanter laterally along the shaft of the femur to a point three inches below the trochanter. The gluteus medius muscle and joint capsule are incised longitudinally. The gluteus medius muscle is widely retracted and entirely freed from its loose attachment at the tip of the trochanter. The vastus lateralis muscle is split longitudinally at its origin and the external lateral surface of the femur is exposed. With a motor saw or osteotome a bone graft, three inches in length, one-half inch in width, and three-fourths inch in thickness, and including the longitudinal mid third of the trochanter, is removed from the external lateral surface of the femur. The removal of the graft affords an excellent view of the femoral neck and full exposure of the fracture. The fracture is reduced by leverage and manipulation. A drill hole is passed, as in the Albee method, through the trochanter and neck into the head of the femur, the length of the drill hole having been previously estimated from a roentgenogram of the opposite normal hip joint. The bone graft is shaped, the periosteum removed, and the graft is driven with its trochanteric end outward into the bed prepared. The wound is closed in the usual manner. The patient is turned on his back recumbent on a sacral rest and a double plaster spica is applied in the required amount of abduction and internal rotation.

The time of the operation should not exceed forty-five minutes, including the application of the double plaster spica. The operation is attended with little bleeding and no shock. The integrity of the important soft structures, including the Y ligament, is preserved. We have not found it necessary to tie any deep vessels. There is no unnecessary manipulation of the fractured fragments and the position of the head is not disturbed. The further advantage of this method is that through a single incision the bone graft is obtained as part of the operative approach to the hip

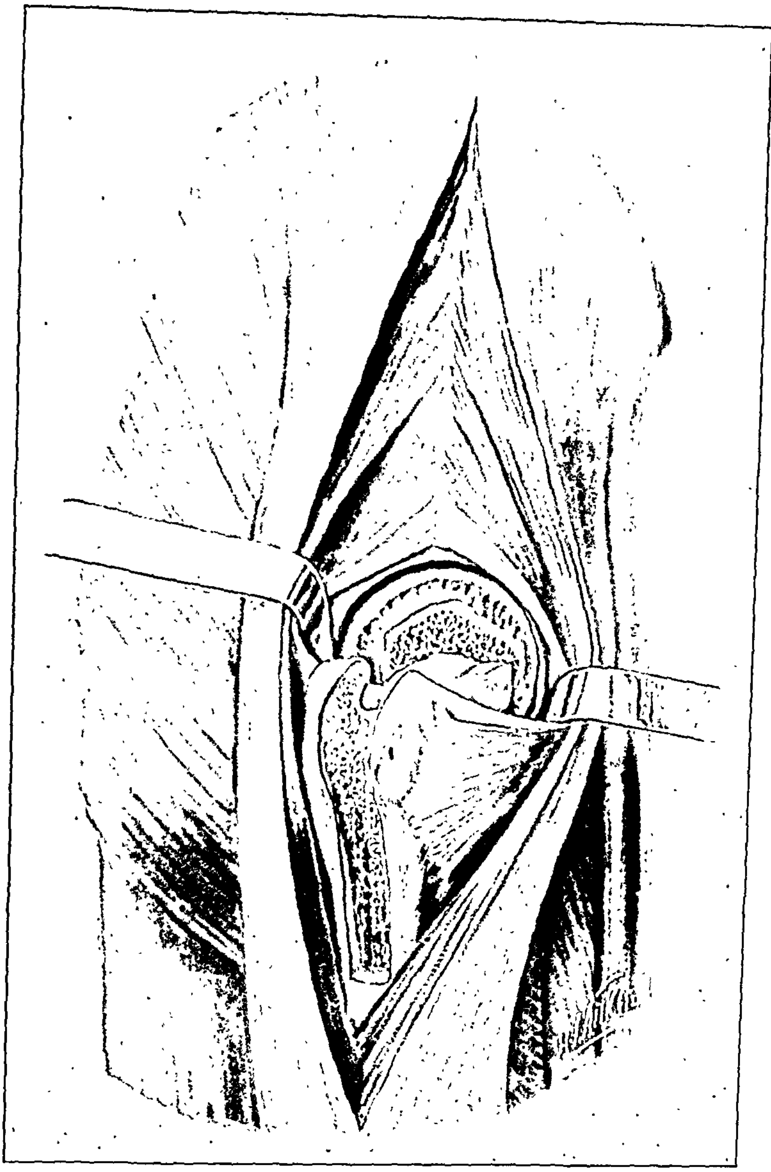

FIG. 1

Showing the external Langenbeck incision extended three inches below the tip of the trochanter. The gluteus medius muscle is split and freed from its trochanteric insertion. The capsule is incised longitudinally. The bone graft has been removed as part of the operative approach, permitting wide exposure and easy access to the intracapsular fracture.

joint. Also, the removal of the mid third of the trochanter as part of the bone graft fully exposes the entire neck and avoids "blind pegging", since with full exposure of the entire length of the fragments, the angle and length of the drill hole is very easily determined.

The trochanteric bone graft is mainly composed of spongy bone, the lacunae of which are filled with hematopoietic tissue, extremely favorable to early vascularization. The graft consists of barely sufficient cortical bone to maintain firm internal fixation of the fracture. The environment of the bone graft is little changed by transplantation, since the operation consists of transposing the trochanteric graft into a recipient bed of cancellous bone of which the graft itself is mainly composed. This is in distinct contrast to the dense cortical structure of a tibial bone graft, composed almost entirely of compact bone, made up of a strong thick framework with small connective tissue spaces which do not contain hematopoietic tissue, and is not as readily vascularized. Also, in the use of a tibial graft implanted into the femoral neck, we have noted in a study of roentgenograms a much slower adaptation of the dense cortical bone to the spongy bed, as indicated by tardy trabeculization.

We have not found it necessary to dowel the graft. The use of this rather oblong graft in a round hole insures a snug fit, further contributing

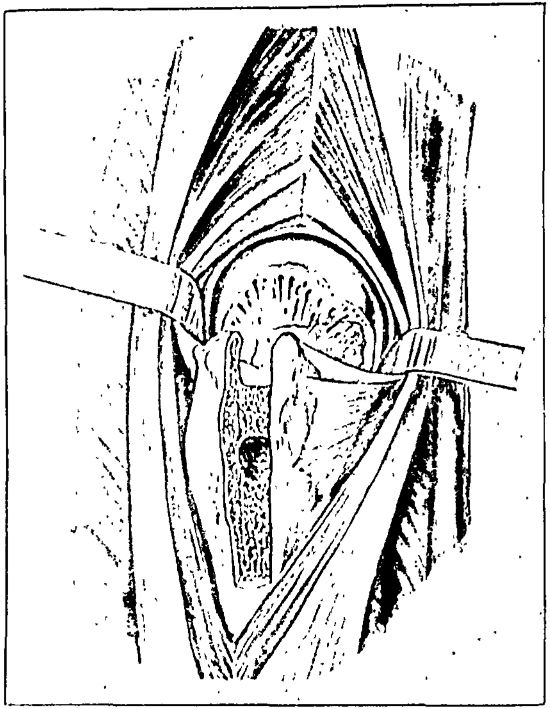

FIG. 2

Showing the fracture reduced and the location and approximate size of the drill hole. The angle of the drill hole is easily determined through this exposure and avoids "blind pegging".

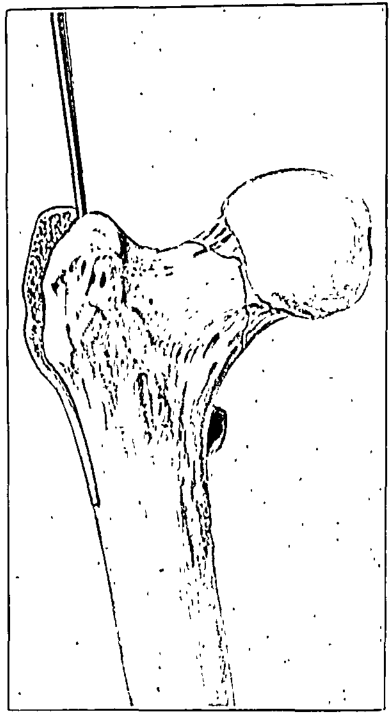

FIG. 3

Showing the depth and extent of the bone graft. The graft is removed with a thin osteotome.

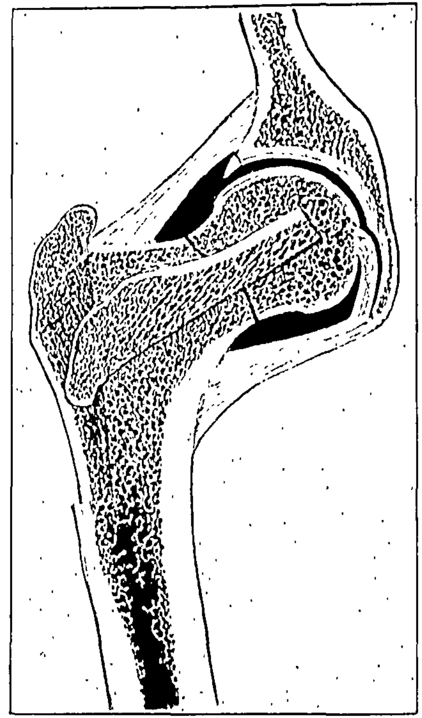

FIG. 4

Diagrammatic section showing the structure of the bone graft. The bone graft is composed of a major amount of spongy bone, encouraging early vascularization, and only a sufficient amount of cortical bone to maintain firm internal fixation.

to firm fixation. We employ a five-eighths inch drill hole to receive a graft approximately one-half inch in width and three-fourths inch in thickness, the graft being composed of cortical bone, approximately one-fourth inch to three-eighths inch in thickness, and one-half inch of cancellous bone. The cancellous bone is sufficiently yielding to permit firm impaction into the bed. The average length of the bone graft employed is two and one-half inches.

The trochanteric defect made by removing the graft from the external aspect of the femur is firmly repaired at the end of eight weeks as in the healing of a peritrochanteric fracture. No muscle attachments are disturbed and the lateral contours of the trochanter are not altered.

SELECTION OF CASES

It is difficult to make an arbitrary division between fractures of the femoral neck requiring conservative treatment by the Whitman method[1] and fractures requiring early operative intervention. We have obtained bony union and good function by the Whitman method in approximately sixty per cent. of patients of all ages up to eighty-one years, and this method has remained the method of choice. If, however, the Whitman method is to be adopted as a more or less routine method of treatment, it is not at all necessary that this choice be final. Operative treatment is justified and indicated in any patient who is a thoroughly good surgical risk and in whom gross comminution and obliquity of the fracture can be demonstrated, or in any patient in whom faulty reduction is apparent after a trial by the Whitman method. Operation is indicated in any patient showing early necrotic changes in the head of the femur, indicating delayed union, and in any patient in whom plaster fixation fails to maintain reduction,—as in the extremely obese type of patient. Also, we believe that failure of union may be predicted from frequent roentgen studies made from the eighth to the sixteenth week in the course of the Whitman method and that timely operative intervention may prevent a non-union otherwise inevitable.

END RESULTS OF WHITMAN METHOD

Statistics on end results of treatment of fracture of the femoral neck by the Whitman method indicate a high average of functional results obtained especially in the hands of surgeons with large experience in bone surgery. Löfberg[2] in 1927 reported 172 cases of intracapsular fracture, in sixty-seven and five-tenths per cent. of which union and good function were obtained. Henderson[3] has obtained bony union in seventy-six per cent. of patients less than sixty years of age and in fifty-four per cent. of patients more than sixty years of age. Reggio[4] in an extremely careful study of end results from the Fracture Service of the Massachusetts General Hospital makes it apparent that the Whitman method gave the highest percentage of good results, approximately sixty per cent. in patients of

all ages. Hey Groves[5] in a series of twelve cases reported seventy-five per cent. of good end results obtained by the Whitman method and a similar percentage of good end results obtained by the pegging operation. He prefers the pegging operation by the Albee method, using a tibial bone graft in the treatment of young, active patients and reserves the Whitman abduction method for elderly, weakly people. Willis Campbell[6], in a large series of patients, claims over seventy per cent. bone union. Stern[7] recently reported a series of patients of all ages in approximately seventy per cent. of whom union was obtained; but he included in his series ten patients from forty to fifty years of age in only thirty per cent. of whom union was obtained. This rather depressing fact makes us pause to consider whether any other method of treatment might not have given better end results. Smith-Petersen[8] has recently advocated operative treatment of most patients with fracture of the hip; he inserts a flanged metal nail for better coaptation of the fragments and firm internal fixation. Attempts have been made during the past few years, particularly by the American Orthopaedic Association, to find out what the end results are in the treatment of recent intracapsular fractures of the neck of the femur, the statistics being derived from the experience of men who have taken especial interest in the subject. Approximately fifty-three per cent. of favorable end results were reported. We may be reasonably certain, however, that the average results in hospital practice are not as good, and the writer believes that not more than fifty per cent. of all patients sustaining a fracture of the neck of the femur obtain a functional end result by any method of treatment now commonly employed.

Henderson[3] and Osgood[9] suggest that perhaps we have been too conservative and that it is possible that we should be dealing with this condition more often by the operative method. There is no reason why the elderly patient should not have the advantages of modern surgery, since it is astonishing how the aged tolerate proper surgery. The writer believes that operative treatment has a distinct place in the treatment of fractures of the neck of the femur and that there remains a relatively large group of patients in whom operation offers the only reasonable opportunity to obtain a good functional end result. So long as most surgeons are content to treat all fractures of the femoral neck by the Whitman method, regarding the choice of this method as final, there can be little hope of raising the percentage of successful end results.

In experiments on the cadaver we have found that a simple transverse fracture of the neck of the femur can be easily and accurately reduced and held reduced by abduction and internal rotation. A comminuted oblique fracture in the cadaver can not be as accurately reduced and, if the fracture is created anteroposteriorly in an oblique manner, extreme abduction and extreme internal rotation separate the fragments, especially if the fracture is artificially comminuted. The obliquity of the proximal fragment so created acts as an anterior inclined plane on which the distal fragment slides, overlapping the proximal fragment anteriorly. Extreme internal

rotation widens the fracture interval. While experiments on the cadaver, because of the distinct difference in tissue resistance to that obtained in the living subject, cannot be regarded as at all conclusive, they are at least suggestive.

Also, in three patients, in whom at open operation through an external lateral incision the obliquity and comminution of the fresh fracture were observed, the same tendency to overriding and separation of the fracture interval was even more apparent. The obliquity and separation of the fragments were sufficient to prevent union, because of inadequate contact of the fracture lines. In a patient, aged sixty years, with an oblique comminuted fracture of the neck of the femur, who was treated—by an associate—by the Whitman method, stereoscopic roentgenograms showed apparently an excellent reduction. After ten days of immobilization in a double plaster spica, the hip joint was explored through an external lateral incision. A gap of approximately three-eighths inch was found between the fragments with approximately one-half inch overriding. It is extremely doubtful that union of such an oblique fracture would have been obtained by the Whitman method.

Albee[10] states that most fractures of the femoral neck are oblique and diagonal and are only infrequently strictly transverse. Stereoscopic roentgenograms will clearly demonstrate the presence of an oblique fracture of the neck of the femur, but, since only an anteroposterior view is available, the exact relation of the oblique fragments to each other and the actual width of the fracture interval cannot be accurately demonstrated. We cannot always be certain, therefore, that the fragments are in exact apposition and contact, even after manipulative reduction.

The small size of the femoral neck, its minimal blood supply, interposition of the torn capsule in comminuted fractures, and the difficulty of obtaining accurate contact in oblique fractures of the neck are factors contributing to non-union. If at operation the interposed capsule can be removed, the fragments accurately apposed, and the early reestablishment of blood supply can be obtained through the fracture line by a bone bridge, open operation would seem to be the method of choice, particularly in this region where long healing time is characteristic and where union is so often delayed and uncertain. It is obvious, however, that open operation should never be attempted where facilities for operative work are not of the highest standard as regards equipment and technique.

Santos[11] has called attention to the early necrosis of the femoral head, following fracture of the neck, and has demonstrated that when bony union occurs, it is by way of new bone coming from the distal fragment of the neck and that reorganization of the head, in case of union of the fracture, proceeds mainly from the connective tissue invading the head from the distal fragment. A bone transplant, passed through the trochanter across the fracture line into the femoral head, taps the richly vascularized area of the trochanter and a bridge formation made up of vascularized tissue proceeds from the distal fragment into the deficiently nourished femoral head.

In selected cases the writer has explored fractures of the femoral neck and endeavored to obtain by the method above described a wide exposure and a clear conception of all the mechanical factors involved in a particular fracture. At operation an accurate reduction is obtained under the eye and internal fixation is maintained by a trochanteric bone transplant re-enforced by adequate external plaster fixation.

The four open operative methods commonly recommended in the treatment of recent fractures of the femoral neck include:

(*a*). Incision and operative reduction of the fracture followed by plaster fixation.

(*b*). The Albee method[10], which requires the transplantation of a tibial bone-graft peg through a hole drilled longitudinally through the neck of the femur, maintaining the fragments in good position. This method, originally recommended by Albee in 1913 for the treatment of ununited fractures, requires three incisions: an anterior hip incision exposing the fracture, an external lateral incision over the trochanter, and an incision over the anterior tibia from which the graft is obtained. The anterior hip-joint incision affords a view of the fracture line, but sacrifices the integrity of the anterior portion of the iliofemoral ligament. The necessity for three incisions lengthens the operative time and adds to the operative risk.

(*c*). The Smith-Petersen method[8], utilizing a metal nail for internal fixation, the nail being inserted from the trochanteric side through the neck into the femoral head.

(*d*). The Hey Groves method[5] of "proximal pegging", presented in 1929. This method consists of opening the hip joint, dislocating the head, and fitting it accurately to the neck with a beef-bone peg. The method has been recently modified by Henry[12] in experimental work on dogs. He utilizes a rustless steel screw introduced proximally through a drill hole, it being possible to remove the screw later from the trochanteric side. This operation requires a wide operative approach with removal of the head, which contributes to a considerable element of shock.

The objection of the writer to the use of nails and beef-bone pegs is that they retard early vascularization, whereas an autogenous bone graft furnishes "an osteogenetic callus-forming influence, serving as a vascular conducting scaffold, conducting blood from the vascularized trochanteric region to the anaemic capital fragment"[13]. This function of early vascularization of the bone graft has been especially emphasized by Albee[13].

The classical method of closed reduction of fractures of the neck of the femur by abduction and internal rotation is a tribute to the genius of Dr. Royal Whitman. The method involves little risk to the patient and it is apparent that the percentage of cases obtaining bony union and good functional end results has been enormously increased since the introduction of this method. Open operation increases operative risk, but certainly the percentage of favorable end results obtained from the conservative method is not yet high enough to justify the acceptance of the Whitman method as a routine procedure.

CONCLUSIONS

The advantages of open operation by the trochanteric bone-graft method may be summarized as follows:

(1). Early and accurate replacement of displaced fragments with assurance that no interposition of tissue exists.

(2). Bridging of the fracture line with an autogenous bone graft, providing firm internal fixation, the graft also acting as a calcium source for the healing granulation tissue (Murray[14]).

(3). Early reestablishment of blood supply between the head and neck of the femur in an area where blood supply is minimal.

We particularly emphasize the conservatism of this method and the ease with which through a single incision the hip joint is widely exposed, an adequate bone graft is obtained from the trochanter as part of the operative approach, and the direction and position of the transplant is accurately determined.

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BACKACHE

An Anatomical Consideration*

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For the last ten years I have been given opportunity to examine all spinal columns after students of the local medical school have finished their dissections. I have found very little disturbance of these spines to indicate any curiosity on the part of the students as to even the gross anatomy of the part. This may explain the difficulties of the average physician when confronted with the problem of backache, as well as the tendency of the surgeon to turn his patient over and remove some of the dispensable parts from the abdomen or female pelvis, concerning the anatomy of which his curiosity has naturally been more active.

There are three particular reasons why consideration of anatomy is of primary importance in a study of backache:

First, because the back is a complex arrangement of many bones, each with multiple articulations, balanced by intricate coordinating muscle groups, every element subject to the various vicissitudes common to its kind.

Second, because as a structure developed for quadrupedal function with a support under either end, it has been forced to manage a right-angle turn and balance in the upright position, thereby acquiring mechanical imperfections and areas of exaggerated stress.

Third, because, due in part to the change of posture, anomalies of development occur with surprising frequency, especially at the points of greatest stress.

There is no need to review before this audience the anatomy of the spinal column and its supporting structures, or the mechanics of the back as affected by posture, injury, or disease.

The spinal column of the quadruped is slightly convex upward from the anterior to the posterior limb supports, between which it is slung on muscles and ligaments. From shoulder to occiput the curve is reversed, the head being suspended by the ligamentum nuchae. Posteriorly the sacrum forms a shorter upward convexity, meeting the primary curve at the lumbosacral angle.

The spinal column of the infant is of the primate type. His hips are flexed and attempts to extend them are met with considerable resistance.

*Read before the American Orthopaedic Association, at Memphis, Tennessee, April 16, 1931.

Forced extension of the hips, through the action of the iliofemoral ligaments and muscles on the sacro-iliac articulation throws the sacrum sharply backward. When the limit of this motion is reached, the same forces plus that of the psoas muscle arch the lumbar spine forward, at the same time intensifying the original curve in the thoracic area. This is the beginning of the spinal curves peculiar to the human being.

Under the efficient bathing, diapering, and swaddling attentions of the modern nurse the infant's thighs can be placed flat on the table top by the ninth or tenth day, particularly in abduction, but he does not actively main-

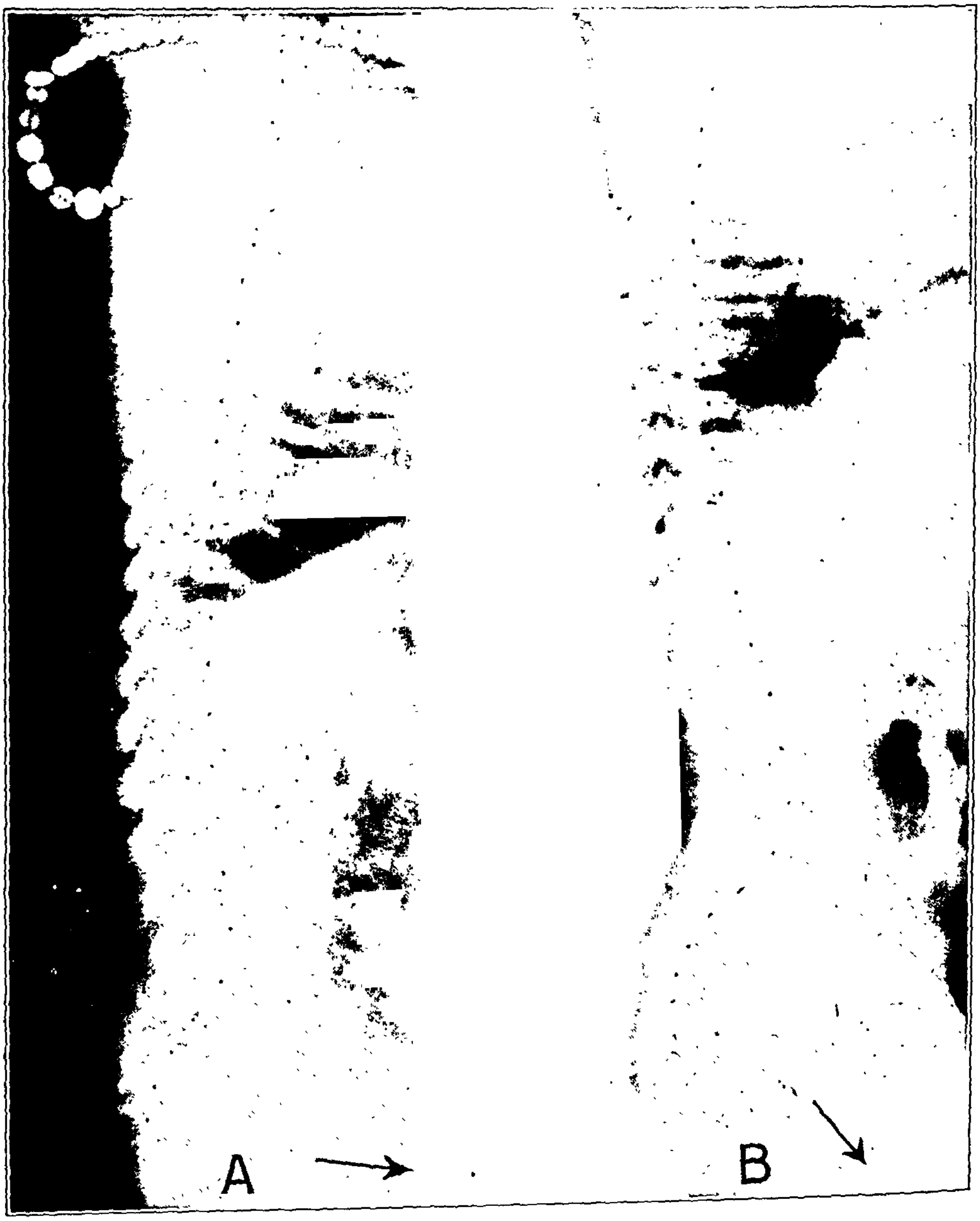

Fig. 1

Lateral view of the spinal column of a twenty-four-hour-old infant.
A. While lying with hips flexed. *B*. With hips forcibly extended.
Note change produced in the lumbar curve.

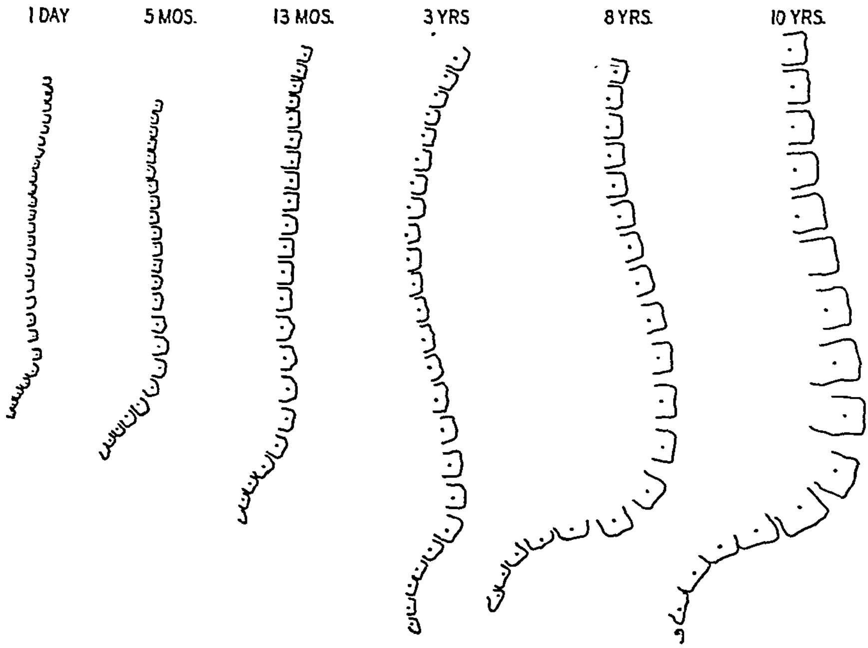

FIG. 2

Tracings made from lateral view x-rays of spinal columns at various ages, the subject lying at ease. All reduced in the same scale. The thirteen-month baby had not yet begun to stand, because of mental deficiency.

tain this position until the third month. How soon these changes would take place without such care is a matter for conjecture.

At five months the curves at rest are slightly more pronounced, but are still markedly increased by extension of the hips. No further changes occur until the child starts to stand alone, when the need of keeping the center of gravity over the area of support results in gradual increase and fixation of the curves. At first both thoracic and lumbar curves are about equally affected, but the lumbar curve soon assumes preponderance and becomes fixed, so that extension of the hips has little or no effect on its value. At about eight years the curves are fully acquired and, though more mobile than later, show no further change. At the points where these normal curves meet, the back is particularly liable to strain and irritation from any source, with resulting sprain or arthritis. Exaggeration of the curves from habit, fatigue, or other cause increases such liability.

From consideration of what may be termed normal anatomy and its relation to backache we turn to discussion of the anomalous. Certain vertebral anomalies found frequently in man occur also in the primates and other mammals,—in fact, in all vertebrates. These are variations in the number of presacral vertebrae, variations in the number of rib-bearing segments, occasional appearance of half vertebrae, irregular fusions of segments, and—of particular interest here—variations in the formation and articulation of the last lumbar and first sacral segments. These anomalies

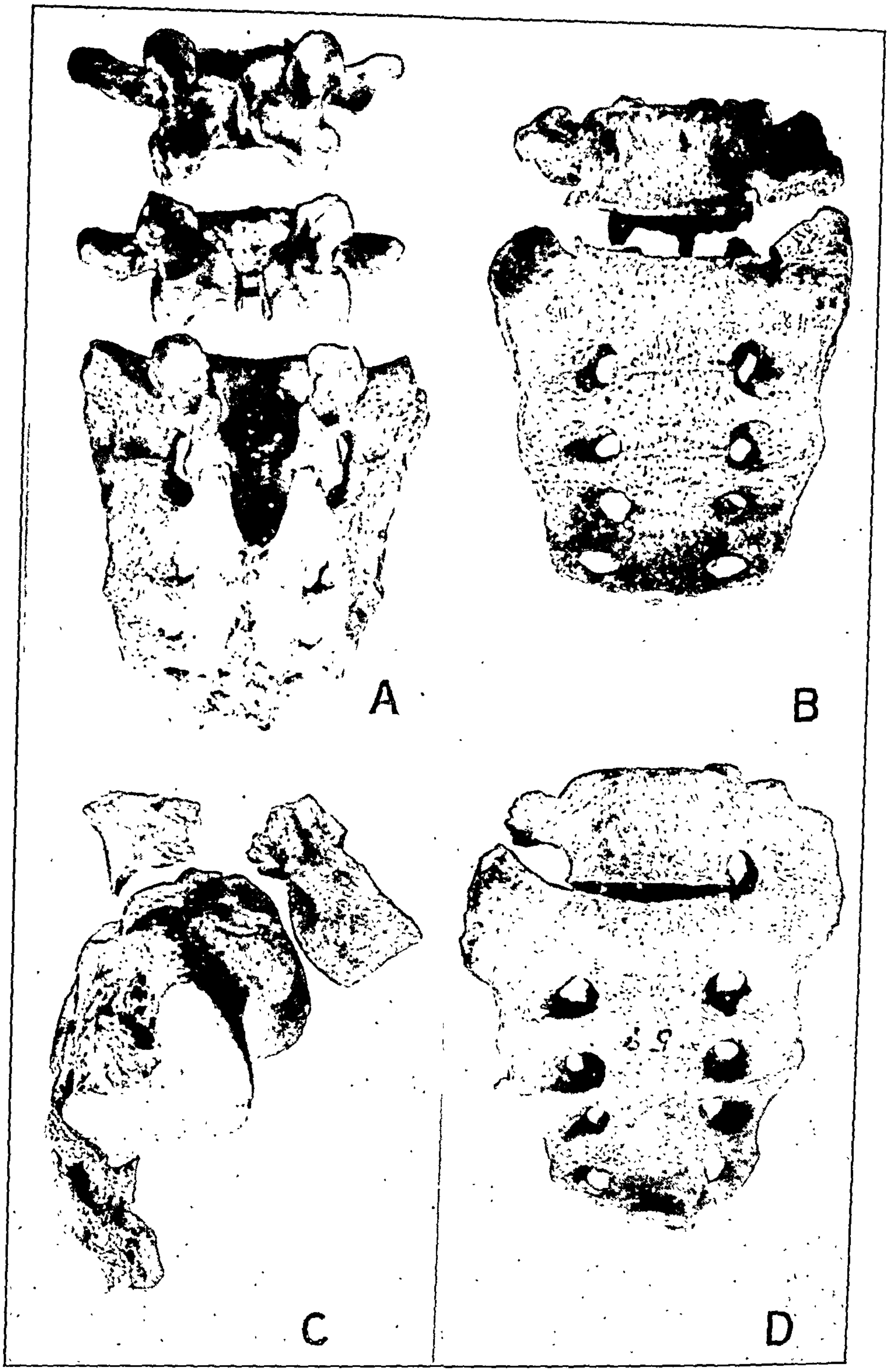

Fig. 3

Common vertebral anomalies.

A. Spina bifida occulta involving the two lower lumbar segments and the sacrum.

B. Articulation of the left lumbosacral transverse processes.

C. Lateral view of the sacrum and last lumbar segment in case of bilateral laminar defect showing the beginning of spondylolisthesis.

D. Unilateral sacralization of the last lumbar segment.

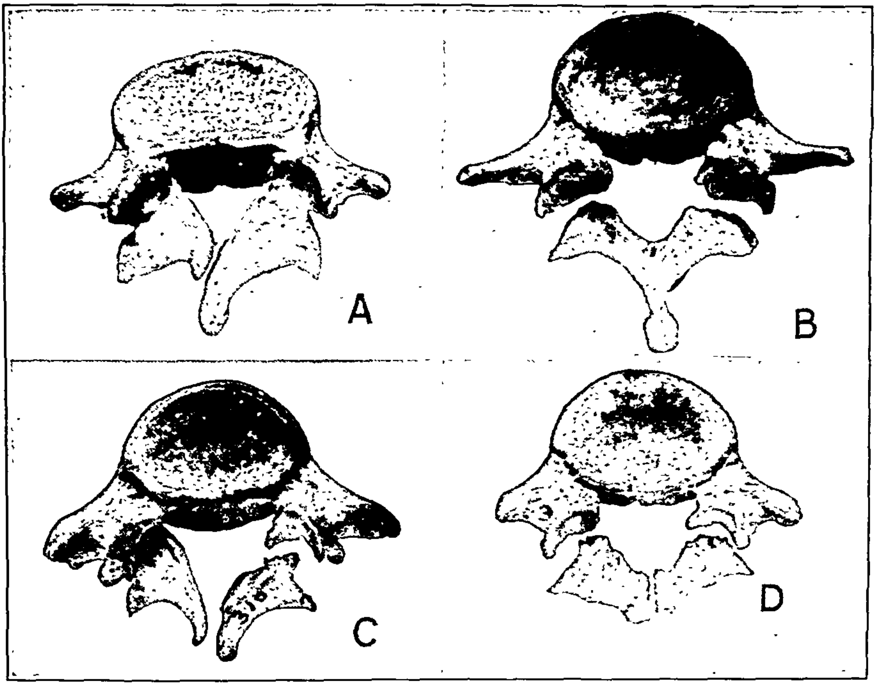

FIG. 4

Last lumbar vertebrae showing neural arch anomalies.
A. Spina bifida occulta.
B. Bilateral defect between the superior and inferior articular facets.
C. Unilateral laminar defect combined with spina bifida.
D. Bilateral defect combined with bifid and undeveloped spinous process.

are common to all vertebrates and are mostly steps in an evolutionary shortening or lengthening of the presacral column accomplished by progression or retrogression of the pelvis and hind limbs on the column. The last presacral vertebra, whichever it may be, shows in all species a decided tendency to variability in its transverse processes and articulations with the sacrum.

Variation in number of presacral segments is of little importance in discussion of backache. Asymmetrical sacralization and defective lumbosacral articulation are of definite interest only as they provide points of lessened resistance to the stresses of function, with susceptibility to muscle and ligament injury. The presence of such an anomaly, as demonstrated by x-ray, does not solve the problem of pain in an individual back, and is not in itself an indication for operation.

An anomaly which occurs in all races of mankind but has not yet been noted in any primate or other vertebrate may be attributed to the assumption of the upright posture. I refer to the condition described as "separate neural arch", a defect of one or both laminae occurring between the superior and inferior articular processes of one of the lumbar vertebrae, most often the last.

This anomaly has long been recognized, but its frequency of occurrence and clinical importance have not been generally appreciated. Its relation to spondylolisthesis is now well known. It is the result of defective ossification of the laminae. In 1923 I found reference to thirty-three instances of the defect and added thirty-one from a study of 748 skeletons. Since then many have been reported: from Russia by Turner and Tcherkin; from African Bantu by Shore, who found the anomaly in six and nine-hundredths per cent. of eighty-two skeletons; by Stewart who finds it in about thirty per cent. of his Eskimo skeletons; by Congdon, working with American Indians in the Northwest; and by many American and European writers. The material at my disposal has allowed me to report recently seventy-nine instances of the defect found in 1520 skeletons (an incidence of 5.19 per cent.).

The defect occurs unilaterally or bilaterally, and with or without fusion of the laminae posteriorly at the spinous process. In sixty-one of our specimens the anomaly was bilateral; in sixteen the right lamina only was affected, in two the left. It was found once in a first lumbar vertebra, once in a third, four times in a fourth, once in both fourth and fifth, sixty-six times in a fifth lumbar, and six times in the sixth. Since only sixty of these 1520 skeletons had a sixth lumbar vertebra, the defect seems to be associated a little more frequently with increased number of presacrals.

In ten instances the lateral defect was associated with spina bifida occulta. In three of these it was unilateral, in seven both laminae were defective, the posterior half of the arch being formed by two separate quadrants.

An intact vertebra is anchored to the segment below by its inferior articular processes. When ossification is interrupted between these and the centrum, stability of the superimposed column depends upon fibrous adherence of the fragments only. Muscle pulls on the anterior and posterior fragments tend to aid the force of gravity in separating them. Actual displacement, spondylolisthesis, may be precipitated by a single tearing of the fibrous attachments, or by gradual and repeated stretching. In either event the symptoms are those of local ligamentous injury, acute or chronic, and referred pain. Until actual displacement takes place, x-ray evidence is usually lacking.

SUMMARY

The human back is particularly subject to aches of muscle, joint, and ligamentous origin because of its complicated structure, its adoption of the upright posture, and because of frequent defects of development in the lumbosacral area, some of which are serious mechanical faults.

THE IMPORTANCE OF THE PERIARTICULAR INNERVATION IN THE PATHOLOGICAL PHYSIOLOGY OF SPRAINED JOINTS*

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INTRODUCTION

In a recent publication, Leriche[1] emphasized the importance of the innervation of the joint capsule and periarticular ligaments in the pathological physiology of articulations. He pointed out that histologists have long since described the abundance of nerve terminations in the periarticular ligamentous tissue, but that little note has been taken of this in the interpretation of certain pathological joint conditions, especially sprains. For instance, in 1865, Rauber[5] pointed out that there were fifteen tactile corpuscles about the interphalangeal joint of the thumb, ninety-six about the elbow joint, etc. Sappey[3], in 1866, stated that "the articular ligaments are as richly supplied with nerve endings as the skin. Some, in fact, have even a greater supply than the skin of the trunk or extremities, and, to obtain a correct impression of the nerve plexuses about the joint, we must compare them with the innervation of the skin of the fingers and toes." Regaud[4], in 1907, described in detail the various types of periarticular nerve endings and insisted again upon their abundance.

Leriche[1] has shown clinically that the sensory innervation of a joint is primarily periarticular. For when an anaesthetic solution is injected into the synovial cavity of a painful, non-distended articulation, the pain is not relieved. On the other hand, when the joint capsule, surrounding ligaments, and adjacent periosteum are infiltrated, relief from pain is practically complete. Not only does the pain disappear, but movements hitherto impossible are executed with facility.

The following six cases of joint traumatism demonstrate the favorable clinical results of periarticular infiltration of anaesthetic solution.

CASE 1. P. A., female, maid, aged twenty-three.

Three days prior to admission the patient "twisted the right knee" in stepping off the side walk. There was severe pain for the next few hours causing the patient to hold her knee immobile, in slight flexion, most of the time. The pain became gradually more severe until by evening she could not walk. The following two days were spent in bed because of this pain.

*From Surgical Clinic A, Strasbourg, France, Director: Professor René Leriche.

Examination on admission revealed the right knee held immobile, in slight flexion, with slight swelling about the joint; no fluid in the joint cavity; no ecchymoses. The joint capsule on each side of the patella was exceedingly tender, and passive moments of the patella produced severe pain. Active movements were not made. Passive flexion was permitted for ten degrees and was painful. Walking was performed with the right knee held immobile and marked favoring of the right leg.

Roentgenograms of the right knee were negative.

Diagnosis: sprain, right knee.

Twenty cubic centimeters of one per cent. novocain solution were injected into the joint capsule on each side of the patella. A few minutes later the patient permitted a passive flexion to forty-five degrees.

A quarter of an hour later, almost full passive flexion and active flexion to ninety degrees were obtained. Palpation about the patella was painless. Walking, however, was still much impaired.

That night the patient experienced a sensation of heat in the joint and at times throbbing pain. Having to arise, however, she was surprised to find that she could walk almost normally.

The following day active flexion was readily performed to about 120 degrees, and walking was almost normal. Practically all spontaneous pain had disappeared.

On the third day full active flexion was obtained and walking was almost normal. Palpation of and about the patella was still slightly painful. The patient stated she felt capable of returning to her occupation as maid, and was discharged.

CASE 2. L. C. (Leriche[1]), male, aged twenty-eight.

A few days prior to admission the patient injured his right knee while skiing. On admission it was found that the joint was slightly swollen, tender, and contained a little fluid. Walking was painful, full movements of the joint were not executed, especially extension. No ecchymoses. Roentgenograms of the knee showed no bone lesion.

The periarticular tissues were infiltrated with one per cent. novocain, and shortly afterward the pain disappeared. Active motion increased, but there was still difficulty in flexion; Leriche concluded that there was a mechanical obstruction. Arthrotomy a few days later revealed a torn meniscus.

Comment. In this case the injection of novocain not only suppressed the pain, but aided in the diagnosis of a mechanical derangement of the joint, since with all pain suppressed, full flexion should have been possible except for some mechanical obstruction.

CASE 3. L. J. (Leriche[1]), male, aged twenty-five.

A week prior to admission the patient struck his right fist against a wall. Following this, there was persistent weakness of the right wrist and some pain. On examination, there was slight swelling and heat about the wrist joint. Flexion was not possible; extension was limited; the grip was weak; there were no clinical signs of fracture. Roentgenograms showed an old fissure in the scaphoid, due to trauma one year previously, accompanied by slight condensation and irregularity of the bone.

Ten cubic centimeters of one and one-half per cent. novocain were injected into the ligaments about the wrist joint, and in a few moments normal flexion and extension were performed without pain.

Two days later the patient was seen again and presented essentially the same picture as before injection. A perihumeral sympathectomy was performed, and by that evening full motion had returned to the wrist. Eight days later the patient was discharged, all symptoms having disappeared.

CASE 4. (Leriche and Jung[2]), male, aged twenty-seven, laborer. One and one-half years prior to admission, the patient stumbled on two occasions, while carrying a heavy weight. He stated that he "wrenched" his back and has not been able to work satisfactorily since because of pain.

Physical examination revealed contracture of the paravertebral muscles with pain on pressure over the tenth and eleventh dorsal vertebrae. The patient, however, was able to pick an object off the floor without bending his knees.

Roentgenograms showed marked compression of the intervertebral disc between the tenth and eleventh dorsal vertebrae. This compression was especially marked on the left, where the vertebral bodies almost touched each other. No bony lesion was present.

The muscles and ligaments on the dorsum of these vertebrae were infiltrated with one per cent. novocain. Ten minutes later another roentgenogram was made which showed complete disappearance of the compression of the disc.

The patient was seen a month later and stated that his relief had been only temporary. A second and similar injection was made with prompt relief. At the end of another month the patient was seen again, still complaining of pain. A third injection was performed, this time followed by permanent relief from all discomfort. The patient has resumed his work in a steel mill.

CASE 5. M. C., male, aged thirty-two, laborer.

Four days prior to admission the patient "wrenched" the middle finger of the right hand while working about a machine. This was followed by swelling and pain in the first interphalangeal joint, with inability to fully flex this joint. The patient came to the clinic because of persistence of the partially impaired function. Roentgenograms showed no bone lesion.

Five cubic centimeters of one per cent. novocain solution were injected into the capsule and periarticular ligaments of the injured joint. Several moments later full active flexion was performed without pain. The patient was seen several days later and normal function remained.

CASE 6. L. S., mechanic, aged forty-two.

One week prior to consultation the patient accidentally struck himself a severe blow with a hammer on the proximal interphalangeal joint of the middle finger of the left hand. There was swelling of the entire hand that night. Pain and marked limitation of motion persisted. The traumatized joint was surrounded by a dense firm oedema.

Roentgenograms showed no bone lesion.

Five cubic centimeters of one per cent. novocain were injected into the joint capsule. This increased the periarticular swelling, but nevertheless a few minutes later almost full active flexion could be made without pain. The swelling was such as to mechanically prevent full extension. All spontaneous pain had disappeared. One-half hour later the pain and limitation of motion returned.

Three days and seven days later similar injections were made again with temporary relief. The patient was finally seen a week following the last injection. The firm swelling about the joint persisted, and movements, although not normal, were greater than before the series of injections. There was no pain, except on strong palpation of the joint.

DISCUSSION

It is usually taught that sprains consist of the overstretching of ligaments about a joint, resulting in minute tears, multiple small hemorrhages, and severe oedema of the connective tissue. Practically nothing is said of the mechanism of pain, which is the most important clinical symptom, and of its relation to the abundant innervation of the periarticular tissues.

As stated above, the pain in these cases is due to traumatisms of the rich periarticular innervation. These traumatized nerves may also be the source of afferent impulses that give rise to the reflex muscular rigidity

present about an injured joint. The favorable influence of novocain injections as described above is therefore due, not only to the pain-deadening property, but also to the fact that the muscular rigidity about the injured articulation is abolished.

The periarticular injection of novocain may prove to be of considerable value in the treatment of sprains and other joint traumata, where no bone or cartilage lesion is present. The rather sudden suppression of pain and involuntary muscular rigidity, permitting active motion without discomfort, has a profound psychological effect on the patient. As the effects of the anaesthetic solution gradually disappear, the patient will, nevertheless, continue to use the joint and, even though some pain returns, the reassurance obtained during the brief period of relief will enable him to continue to use the joint in spite of some discomfort. In this manner a patient who really desires a return of function will reduce to a great extent his period of disability.

In some patients return of periarticular sensibility is accompanied by return of all symptoms and full disability. In these cases several injections with at least twenty-four-hour intervals may be performed.

SUMMARY

1. The sensibility of a joint is primarily a periarticular sensibility, due to the abundance of nerve endings in the joint capsules and periarticular ligaments.

2. In sprains, pain is due primarily to trauma of the periarticular innervation. Reflex muscular rigidity, involving the injured joint, also has its origin in the traumatized nerves of the joint capsule and ligaments.

3. Periarticular injections of novocain have a definite therapeutic value in the treatment of sprains. The pain and reflex muscular rigidity abolished, almost normal function is possible. In some instances the improvement is more or less permanent; in other cases several injections are necessary.

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CONGENITAL DISLOCATION OF THE HIP IN OLDER SUBJECTS*

Based on a Study of Sixty-Six Open Operations

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Open operation for congenital dislocation of the hip has, in recent years at the Hospital for the Ruptured and Crippled, been reserved almost wholly for those cases that have either resisted previous attempts at closed reduction, or, by reason of the age of the patients, have not been candidates for the closed reduction method. A total of fifty-six cases have been reviewed, all of which were operated upon in the nine-year period from 1922 through 1930, and all were between three and twenty-five years of age. Of this total number the author has operated upon fourteen patients in this and other hospitals, and the remaining forty-two have been operated upon by other members of the Staff of the First Division. Of the total number of cases, forty-two were females and fourteen males. The left hip alone was dislocated twenty-two times, the right hip fifteen times, and there were nineteen cases in which both hips were dislocated. The total number of

Fig. 1

Roentgenogram of Case 16 six years after a reaming and shelf type of operation had been performed.

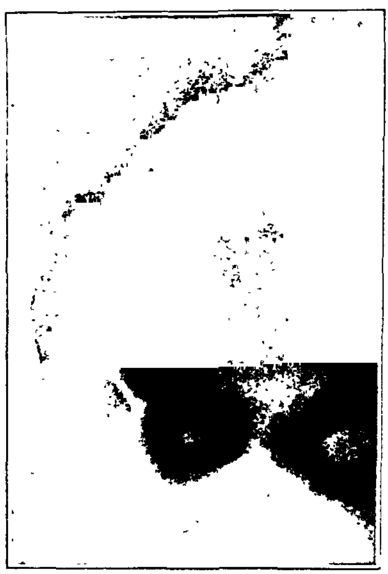

Fig. 2

Roentgenogram of Case 2 showing the left hip nine years after a reaming type of operation.

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hips operated upon was sixty-six, almost all of which had had previously one or more attempts at closed reduction either in this clinic or elsewhere. Forty-seven of the patients were over five years of age,—that is, over eight-three per cent. of all these cases at the time of open operation were beyond the age period when attempts at closed reduction might be expected to yield satisfactory results. The histories have been reviewed and most of the cases have been personally examined from one to nine years after operation in an attempt to evaluate the types of operation commonly employed in this clinic for the so called irreducible hip.

A method of open operation is described which is thought to be applicable during the period of childhood, and three cases are presented in which this method was used.

ANATOMICAL CONSIDERATIONS

The normal relationship of the head and shaft of the femur to the vertical and horizontal planes of the pelvis are of importance in considering the methods of treatment for congenital dislocation of the hip. The ideal is reposition at the level of the original acetabulum with stability and mobility

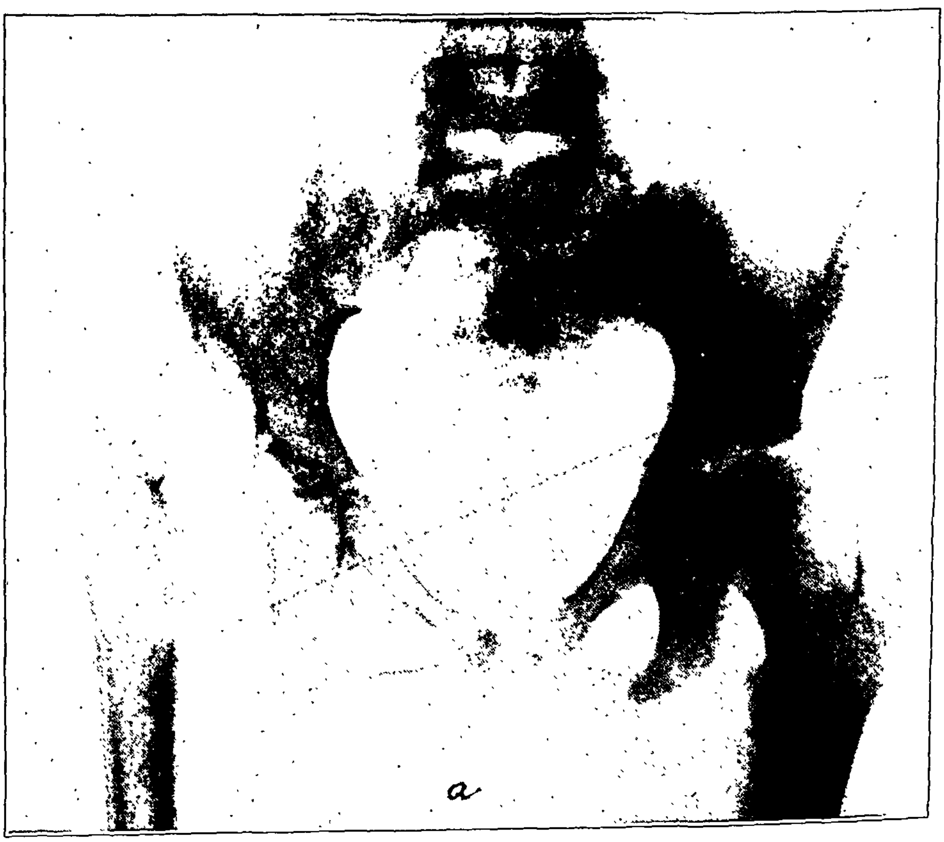


Fig. 3-A

Roentgenogram of Case 29; *a*, before operation; *b*, six months after operation; *c*, four years after operation. Showing the tendency of the hip to go into adduction following the reaming type of operation. This is a painless stable hip, and the patient walks well.

FIG. 3-B

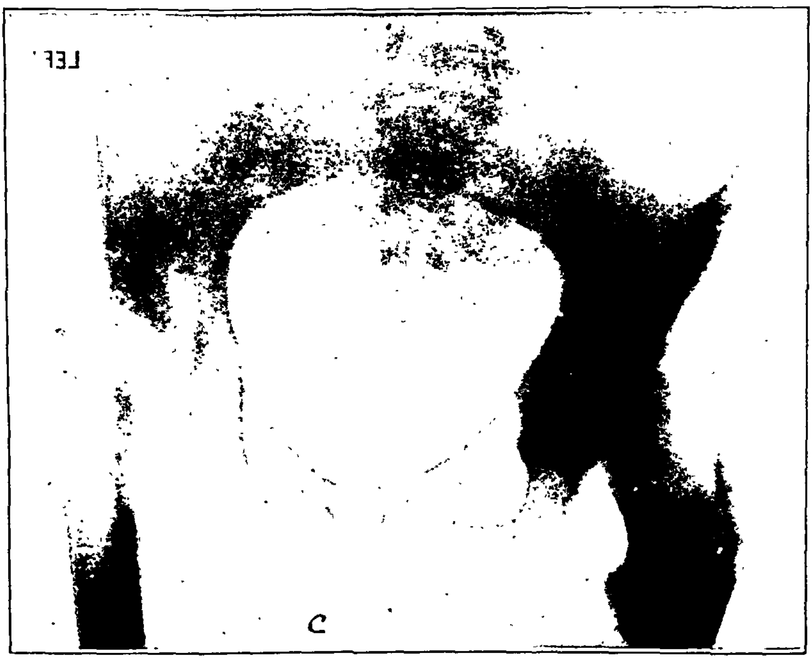


FIG. 3-C

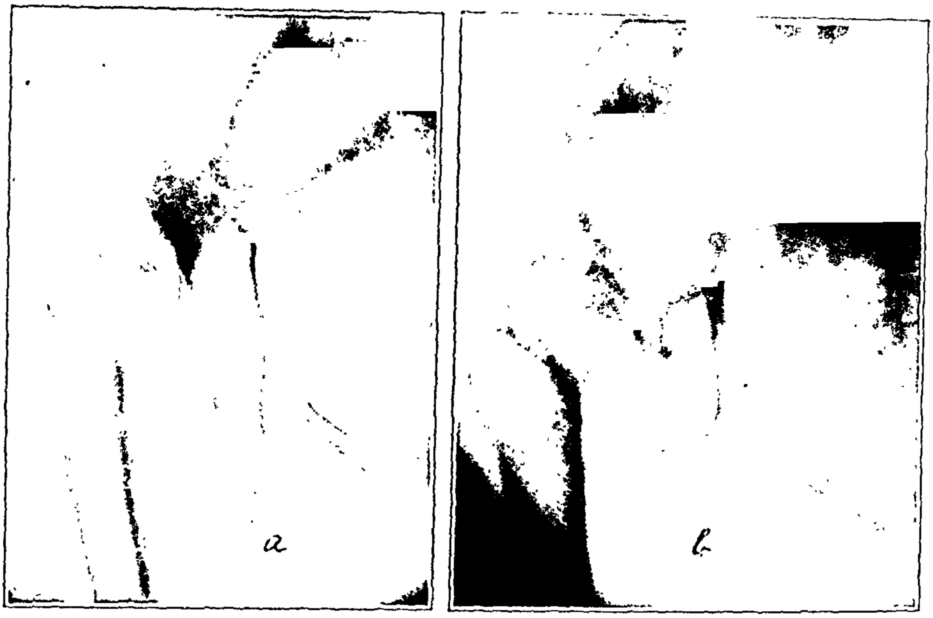


FIG. 4

Roentgenogram of Case 30; *a*, before operation; and *b*, three years after operation, showing the result of a shelf turned down from the dorsum of the ilium.

assured, but it is physically impossible to accomplish this reposition in certain resistant young patients and in most older subjects.

Obstacles to a satisfactory reduction are maldevelopment of the acetabulum, hour-glass contraction of the capsule, and the shortened pelvi-trochanteric muscles. Fairbank in the *British Journal of Surgery* has discussed the anatomy of congenital dislocation of the hip based on a study of thirty-five museum specimens of forty-six dislocated hips, as well as upon a large number of cases personally operated upon. His conclusions are most interesting and valuable. He believes that the underlying fault in the development of the dislocation is primarily a poorly developed acetabulum. In this connection it is interesting to note that Lewis A. Sayre described the condition, almost fifty years ago, as "a congenital malformation of the acetabulum". As the patient grows older and the influences of weight-bearing become more marked, the head usually travels upward and backward. The acetabulum becomes triangular in shape with the base toward the obturator foramen and the apex pointing upward and backward. The depth becomes increasingly less and the remaining portion becomes filled with cartilage and fibrous tissue. In the older cases a false acetabulum may often be identified, lying above and behind its original position and being somewhat larger than the head of the femur. Fairbank has called this area the "auricular retro-acetabular impression". In a few of the older cases it has been very surprising to discover at the time of operation a well marked roof to the original acetabulum which from the roentgenogram appeared to be quite shallow. There are definite changes that can be noted in the older anatomical specimens, both on the ilium and ischium. They become roughened by extra strain on the ischiocapsular

ligament. It may be noted that the epiphyseal center appears later and is smaller than in the normal hip and, as the head is relieved of the stresses and strains of normal weight-bearing, it also undergoes corresponding accommodative changes. The head may become flattened, acorn-shaped or almond-shaped, and may in the adult cases show a varying degree of erosion, depending upon the amount of trauma to which it has been previ-

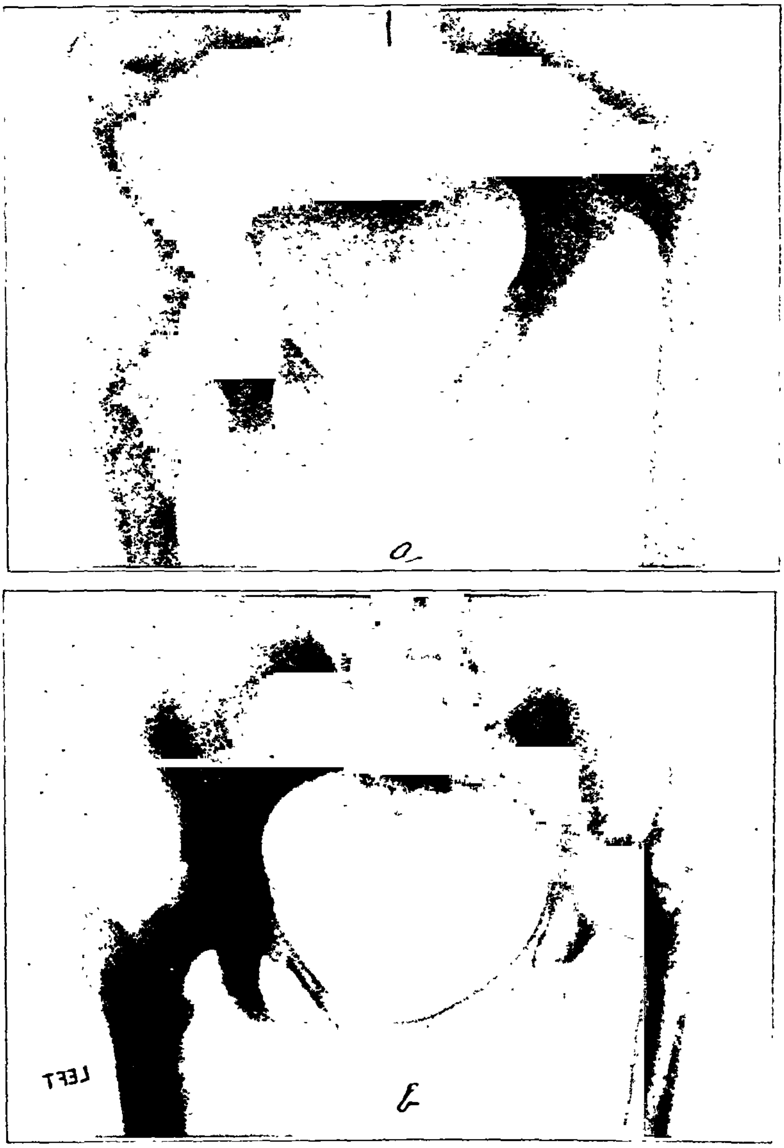


FIG. 5

Roentgenogram of Case 24, showing *a*, before operation; and *b*, taken five years after a shelf operation.

ously subjected. The neck of the femur also partakes of a certain degree of distortion, and smooth polished facets have been noticed on the superior surface of the neck, due to the rubbing of the capsular ligament.

The degree of torsion present is a varying one. Whitman has suggested that at birth the normal torsion is about thirty-five degrees, but that in the normal hip under the conditions of weight-bearing this becomes lessened to about ten or fifteen degrees. If the hip is dislocated, this reduction does not take place to the same degree. The accurate estimation of the angle of anteversion or distortion in the living subject presents considerable difficulty. The method suggested by Stewart and Karshner, who use the fluoroscope, would appear to be relatively accurate. They state, "The patient lies prone with the knee on the affected side flexed to a right angle; the tibia vertical. The foot is carried over towards the sound side and the femur is externally rotated until the head, neck, and shaft appear to be in line. By means of a graduated arc and pointer this angle is measured; the result subtracted from ninety gives the angle of anteversion."

In certain cases anterior distortion is a real factor in rendering the reduction less satisfactory. In this series of older cases, osteotomy to correct the distortion was done in six cases. A much rarer finding, which I believe does occur occasionally, is retroversion, and when found should be corrected by osteotomy. Another frequent change in the bony structure of these cases is in the length of the femur and tibia. It may be of some practical importance to determine this preoperatively. Therefore measurements not only from the anterior superior spine to the internal malleolus on both

FIG. 6

Roentgenogram of Case 31; *a*, before operation; and *b*, taken a year later. A reaming type of operation combined with shelf from the dorsum of the ilium was used in this case.

sides should be made, but also from the tip of the greater trochanter to the external malleolus.

The well known hour-glass contraction of the capsule is a common obstacle to reduction and is more marked in those hips subjected to repeated attempts at closed reduction. In the eighteen open operations personally done on children over five years of age, it was found contracted in every case.

The ligamentum teres has varied considerably in these cases. In a few of the younger children it was absent, in others attenuated and running from the head to the old acetabulum. In the older subjects it was usually completely absent or existed in the shape of a frayed-out fibrous tab. In one child of twelve it was a wide ribbon-like band about an inch long attached to the head.

The pelvitrochanteric group of muscles are always shortened. The abductor muscles especially are trying to perform their work under marked mechanical disadvantage. Therefore, while there is a primary defect in the development of the acetabulum with accommodative changes in the femur, ischium, and ilium, the forces of stress and strain when walking are carried principally by the muscles and ligaments, especially the capsular ligament over the neck of the femur.

Pain in these cases was rarely a symptom except when there was present in the adult patient some degree of arthritis. The most common symptom is usually that of becoming easily fatigued, com-

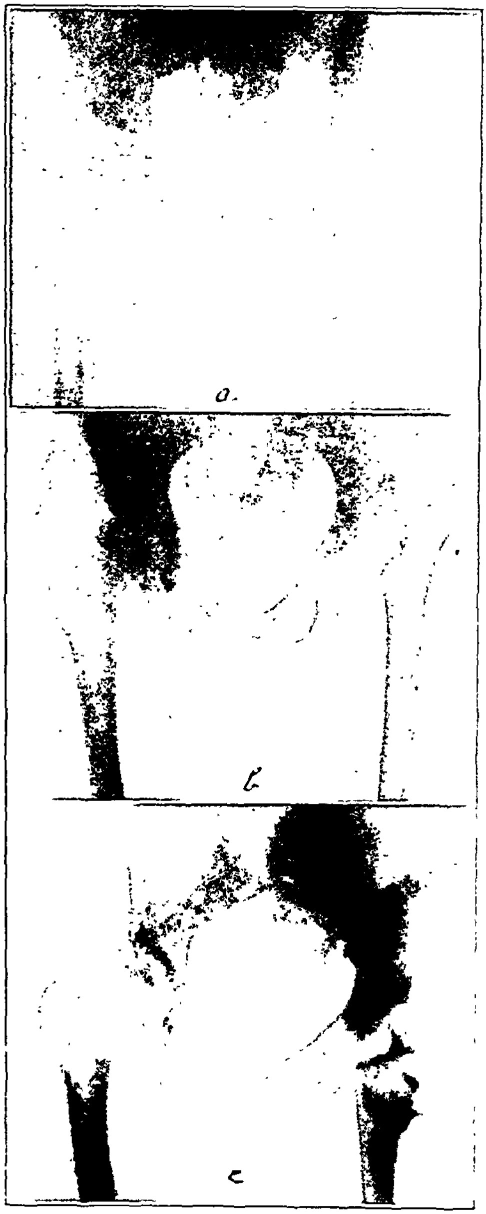


FIG. 7

Roentgenogram of Case 20; *a*, before operation; *b*, five years after a reaming type of operation following which flexion-adduction deformity developed, necessitating another operation; *c*, roentgenogram taken a year and a half after a Lorenz bifurcation operation. A small imbedded portion of a drill remains. The patient walks quite well.

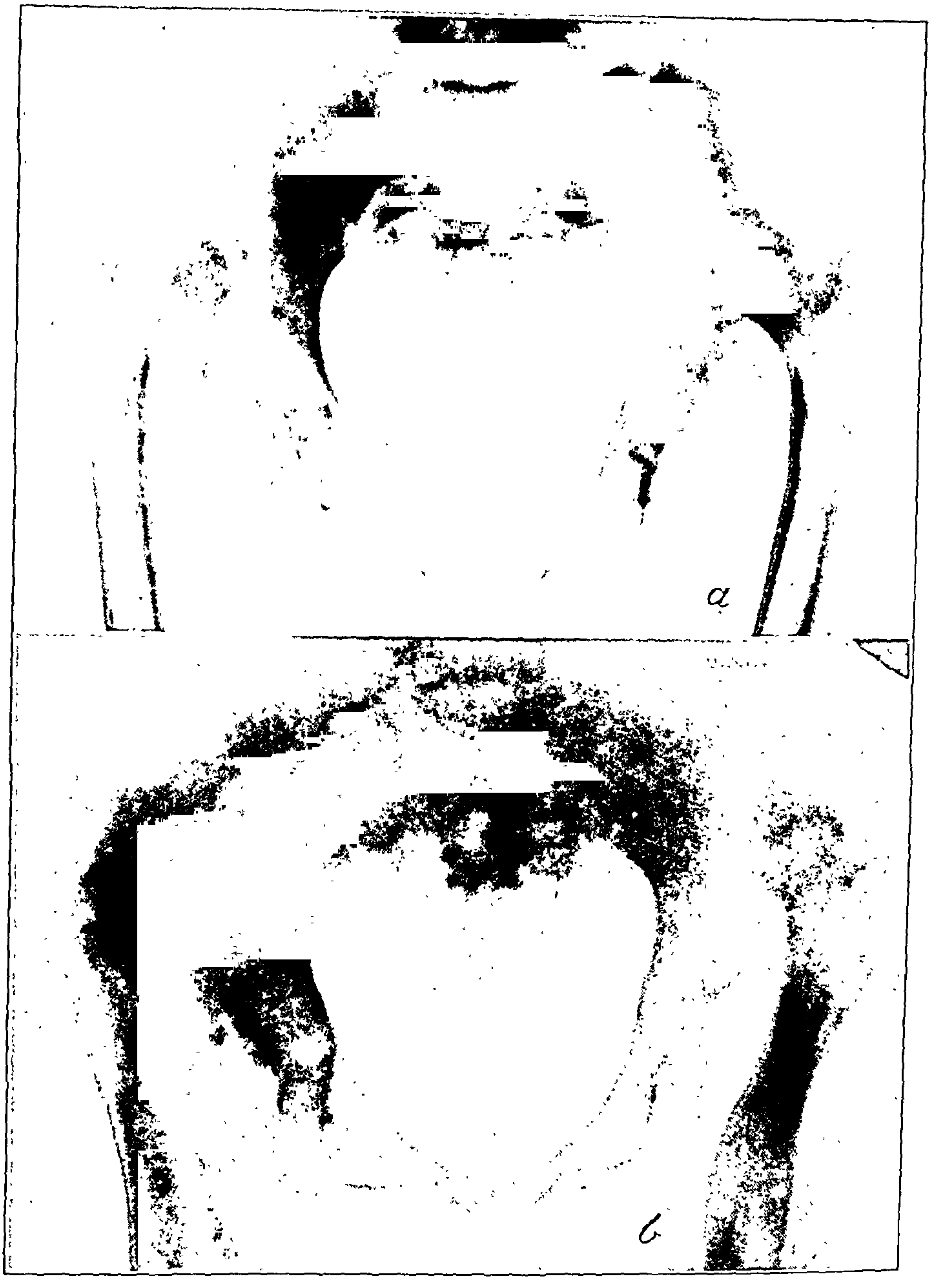


FIG. 8

Roentgenogram of Case 38, showing result of bilateral bifurcation operation after five years. The operation has permitted a decrease in the lordosis but the bony architecture of the femur has been almost completely restored on the right side in spite of the bifurcation. On the left the bifurcation has been more satisfactory.

bined with the characteristic limp such as would be caused by a shortened and unstable extremity. In the adult complaining of no pain, but only giving a history of fatigue on walking, it would appear to be somewhat questionable whether any treatment, other than restricting the activity or raising the shoe, is justified. In the younger case, if an attempt is to be made at open operation to place the head of the femur without undue

tension in its approximately normal position, it would appear necessary that the shortened and contracted soft tissues be sufficiently stretched preliminary to open operation. The factor of trauma to the cartilage and soft parts during a closed reduction is being increasingly recognized as an essential factor in the ultimate function obtained. This important factor of trauma is universally condemned today in all attempts at closed reduction, but is not so carefully observed in those cases coming to open operation.

FIG. 9

Roentgenogram of Case 26 taken about three years after operation, showing the result following the Lorenz bifurcation on the left.

The following preliminary treatment has been found of value: A thorough stretching of the affected hip under an anaesthetic and subcutaneously tenotomizing the adductor muscles permit a certain degree of relaxation to be obtained in the soft structures about the hip joint. A long plaster spica is then applied to the unaffected side and moleskin traction of twenty-five to thirty-five pounds is effectively maintained on the dislocated side. The head has been pulled down opposite the original acetabulum in several children twelve years of age, preliminary to open operation, but those under ten years lend themselves best to this form of preliminary treatment. The resistance of the tissues varies decidedly in individual cases, but usually two to three weeks will suffice to obtain the optimum relaxation and it is felt that the prognosis for ultimate function can be to a definite degree based on the amount of relaxation obtained preliminary to open operation. The operator should not permit himself to be hurried into operating until he is convinced that the stretching has reached its maximum.

The simplest form of reduction is replacement of the head in the original acetabulum. Within the older age period which we are considering, this method has a limited application, but when operation is necessary the earlier it is done the better. Galloway has been the chief exponent in advocating early open operation, and even under the age of three years he has frequently found the constriction of the capsule sufficient to prevent a satisfactory replacement until the contracted portion of the capsule was enlarged. Simple replacement over the age of three years was done in seven cases in this series. One obtained an excellent result both as to stability and mobility; one became infected, the result being a stiff hip; the other five hips, as far as can be learned, have redislocated. Therefore, we

must conclude that in these older cases, except in that very rare type when at operation the acetabulum is found deepened by a well formed superior rim, replacement of the head in the old acetabulum after simply enlarging the contracted capsule will be unsatisfactory, and render a redislocation most probable. While age is not always a fair criterion, and each case must be individually judged, it is felt that as a rule cases over five years of age will not lend themselves to a satisfactory reduction by this method.

Another procedure which has been frequently employed in these older children has been to ream out a capacious socket at or near the site of the original acetabulum, using the Doyen reamer or large curet. In a very few cases the head has been remodeled also, but usually the cartilage covering the somewhat distorted head has been untouched, placed in the newly formed acetabulum and a long plaster spica applied with the hip in full extension and about fifteen degrees' abduction. This method has been used in thirty-one hips of this series. It has the great advantage of assuring stability and, when the reaming is done at the site of the old acetabulum, the normal relationship of the pelvis and femur in its vertical and horizontal axes is restored. There may develop in the joint some degree of movement, but usually this is slight. This type of operation has been almost wholly employed in the unilateral case. A tendency for flexion-adduction to develop must be borne in mind and some of these cases have been readmitted to

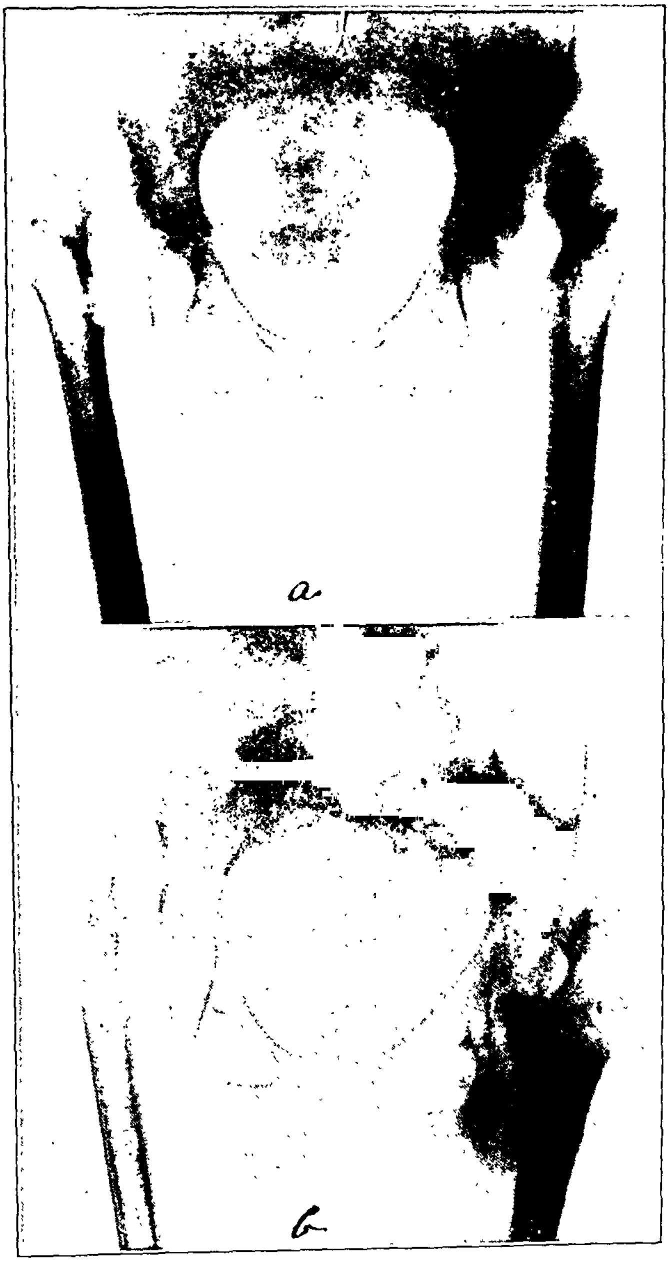


Fig. 10

Roentgenogram of Case 33; *a*, before operation; and *b*, showing result of Lorenz bifurcation on the right side four years later.

the hospital at a later date for correction of that deformity. The children having this type of operation have usually obtained a stable, painless hip and a distinct improvement in gait. If the head is replaced at the site of the original acetabulum and not above or behind it, these patients may often walk with a barely perceptible limp.

In thirteen of these hips some type of osteoplastic buttress was used, combined in five hips with the reaming type of operation. This osteoplastic buttress method was first suggested by König and has been employed in different forms by many other operators, especially Albee, Dickson, and Gill. It would appear to be particularly useful in permitting a satisfactory degree of mobility and in assuring usually a stable hip. One objection advanced against this type of operation is the limited amount of abduction it permits, but in the cases examined it appeared to be usually more than, or at least equal to, that present in the preoperative examination. If at the operation the head can be brought forward, the lordosis and characteristic limp will be greatly lessened by the shelf type of operation. In those older children reexamined with irreducible hips the operation has assured them stability and mobility.

A third type of operation, the Lorenz bifurcation, was employed in eight hips in this series. In the older cases presenting marked discomfort and disability, it is of special value. Stability has been obtained and a surprising degree of mobility. The postoperative alteration of the bones under the forces of weight-bearing is strikingly shown in the roentgenograms taken several years after operation. The gait in six cases personally examined appeared to be distinctly improved in comparison with the preoperative condition.

In four hips anterior transposition was resorted to, the results being a distinct improvement in stability over the original position. A certain

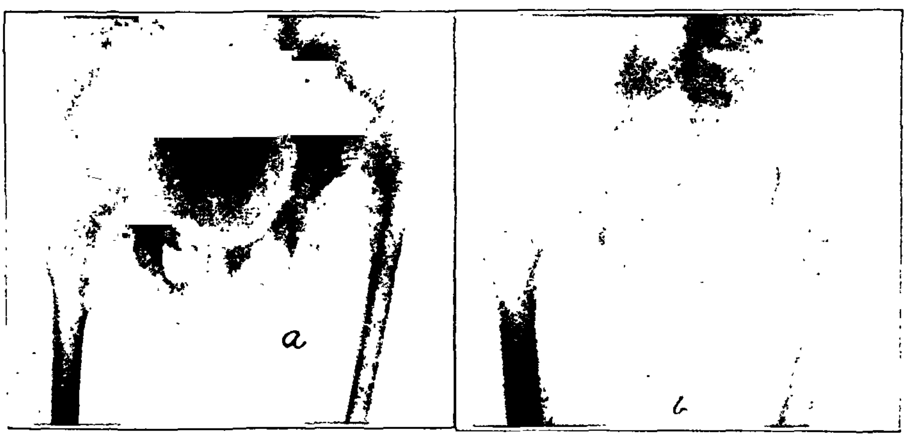
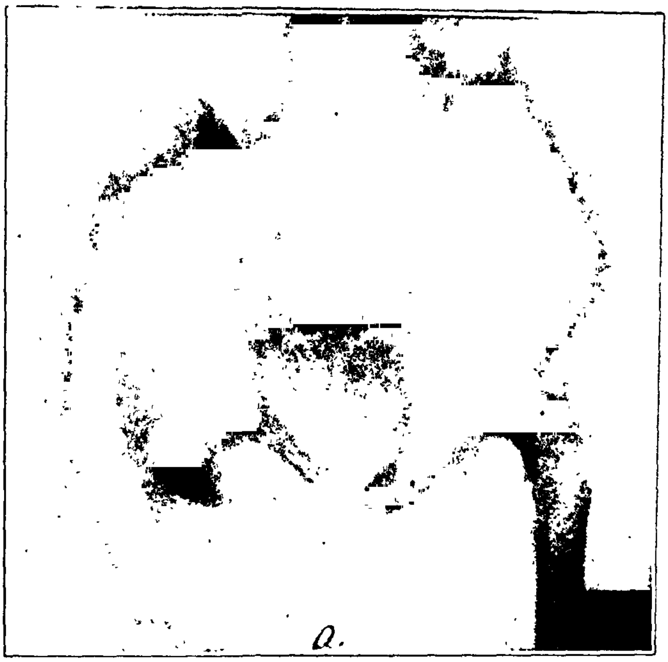


FIG. 11

Roentgenogram of Case 43: *a*, before operation; and *b*, two years later. An anterior transposition resulted with an excellent functional result.

degree of mobility was retained and, while the gait appeared improved, the complaint of fatigue after walking short distances remained about the same.

Another somewhat different method from those described has been personally used on four hips. In 1927 Hey Groves suggested that mobility and stability with an actual reduction of the dislocation might be accomplished if the capsule surrounding the head be placed in a reamed-out acetabulum located at its original site. He suggested perforating the floor of the newly formed acetabulum with a drill and, by means of a suitably curved aneurysm needle, a stout tendinous



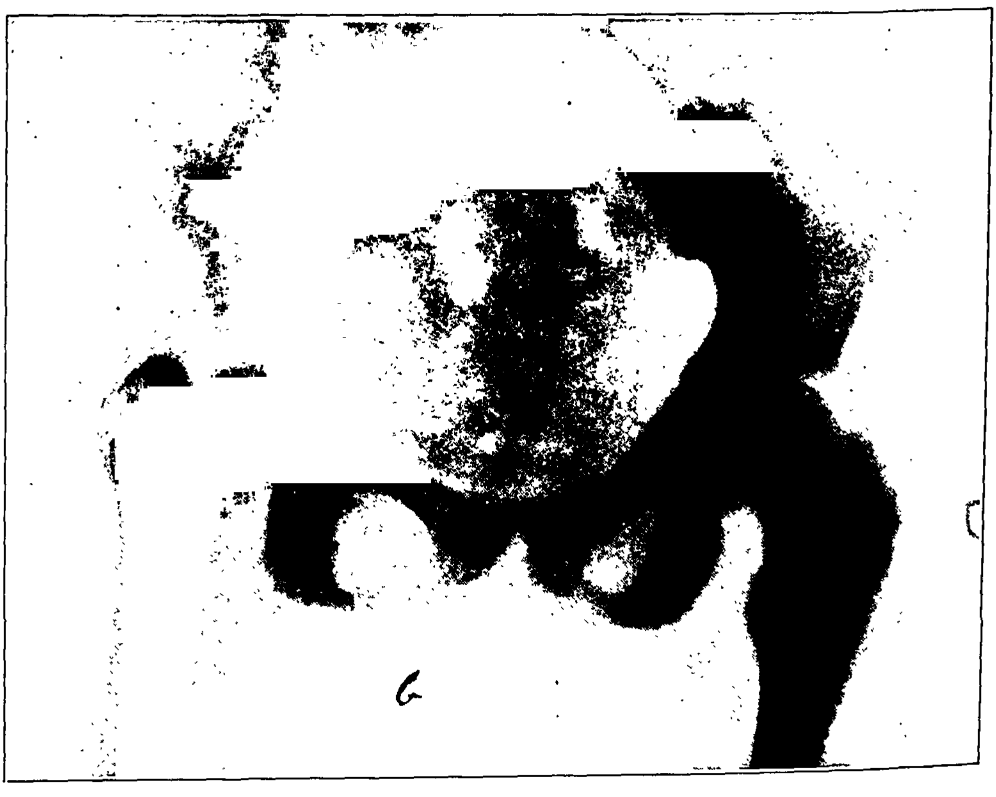


FIG. 12

Roentgenogram of Case 44; *a*, before operation; and *b*, one year following operation.

ligature be passed over the pelvic brim through the hole in the acetabulum and out into the thigh, to be attached to the capsule covering the head. This ligature was then to be tightened and the free margin of the capsule firmly attached to the brim of the pelvis or to Poupart's ligament. I can find no record of any operation done by this method reported in the literature, but the idea of employing the capsule, so as to keep the head of the bone surrounded by the original synovial sac, appeared promising and has been tried with four hips. The method employed was as follows: Preliminary stretching and tenotomy was done and a long plaster spica applied to the opposite side. Several weeks of heavy skin traction permitted the head of the femur to be drawn down near the level of the original acetabulum. When this was accomplished, the child was prepared for open operation and an incision similar to that used in the Whitman reconstruction operation was employed. The greater trochanter with its attached muscles was chiseled through and turned upward, and the capsule covering the head was rather easily dissected free from the surrounding tissues. When the isthmus of the capsule was reached, it was cut through and the head of the bone inspected through this aperture to note the shape of the head and the appearance of the ligamentum teres. The aperture in the capsule was then closed with several chromic sutures. The rectus femoris tendon at its origin from the anterior inferior spine was identified and divided. With the Doyen reamer a capacious acetabulum was formed as near the original site as the pre-

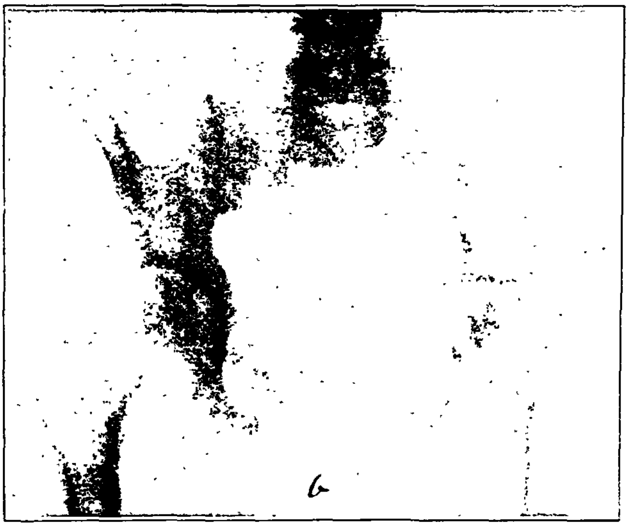


FIG. 13

Roentgenogram of Case 49 in which reduction of dislocation was accomplished preserving capsular covering about head intact; both being placed in reamed-out socket near site of original acetabulum; *a*, before operation; and *b*, a year and a half later.

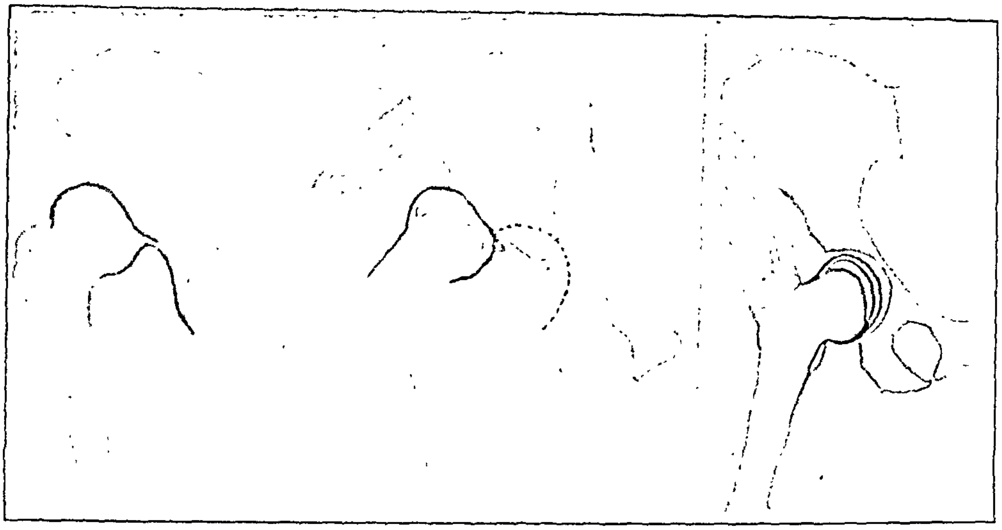


FIG. 14
Diagram illustrating operative procedure used in Cases 48, 49, and 51.

liminary traction had made possible. The head of the bone with its covering of capsule was then placed in the newly formed acetabulum and, with the limb in abduction, the greater trochanter was sutured back into place. After the wound was closed, a long plaster spica with the limb in complete

FIG. 15
Roentgenogram of Case 48. On the left side reduction of dislocation was accomplished, preserving capsular covering about head intact; both being placed in reamed-out socket near site of original acetabulum; *a*, before operation; and *b*, a year and a half later.

extension and moderate abduction was applied. Care was taken not to remove the moleskin from the thigh and leg at the time of open operation, so that immediate postoperative traction could be applied. The roentgenograms of these four cases are here included and show in the last three hips done a stable hip with restoration of the joint space. In the first case, a girl of twelve years, the reduction into a new acetabulum formed at the site of the original was effected satisfactorily. It is felt that the acetabulum in this case was not made capacious enough so that when both capsule and head were replaced in it they were under marked tension. Stability with the limb in moderate abduction has been obtained, although the hip one year after operation presents only a few degrees of mobility. In the second case, a boy of six, satisfactory reduction with a range of motion from 180 to 160 degrees was obtained. In the third case, a girl of six, stability was obtained with a range of mobility from 180 to 120 degrees on both sides.

It is felt, therefore, that this type of operation in children between the ages of three to ten years is worthy of a more extended trial.

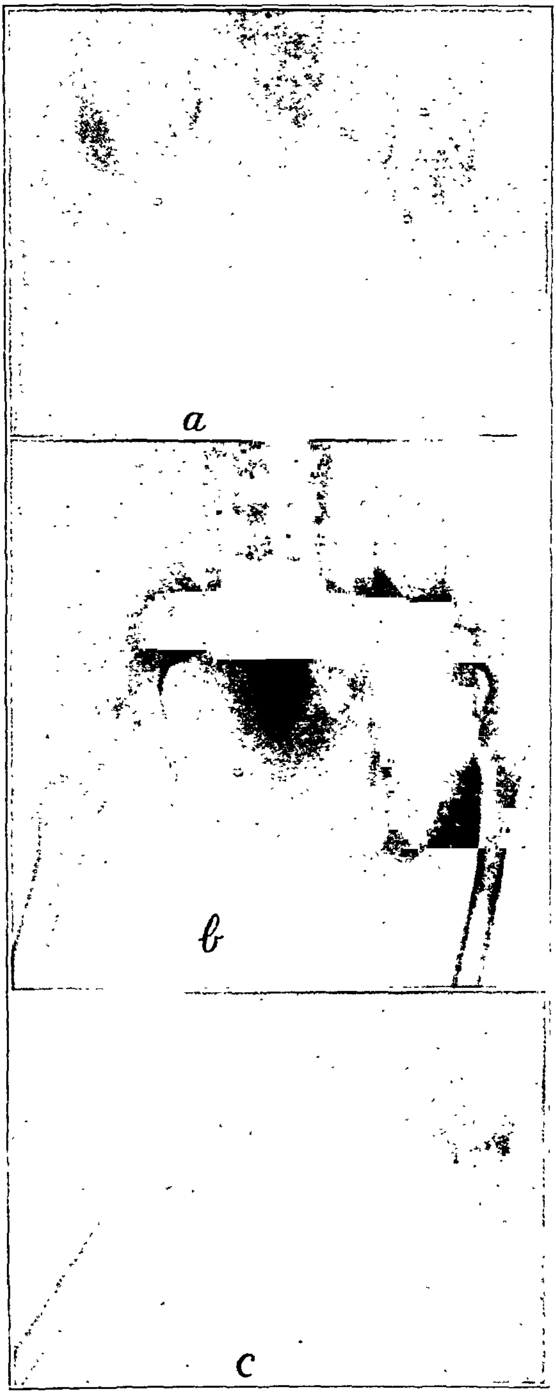


Fig. 16

Roentgenogram of Case 51 in which reduction of dislocation was accomplished, preserving capsular covering about head, both being placed in reamed-out socket near site of original acetabulum; *a*, before operation; *b*, one year after open reduction of the left hip; *c*, one year and a half later, six months after open reduction of the right hip.

TABLE I — CASES REVIEWED

Year	Case No.	Name	Sex	Age	Hip	Date of Operation	Operator	Type of Operation	Follow-up Records
1922	1	B. B.	F.	12	Bil.	L. 4-10-22 R. 12-11-22	R. W.	Head remodelled, acetabulum reamed. Reconstruction operation.	Walks with swaying gait. L. AGE* 180°, AGF† 120°. R. AGE 180°, AGF 130°.
	2	N. C.	M.	6	L.	5-15-22	R. W.	Reaming, head also reshaped.	Range of 10° in all directions. Stable, painless hip.
	3	S. B.	F.	3	L.	4-24-22	R. W.	Reaming and subtrochanteric osteotomy to correct torsion.	Walks with a very slight limp. X-ray shows slight upward displacement above reamed-out acetabulum.
	4	D. S.	F.	16	Bil.	L. 9-25-22	W. S.	Replacement, no attempt made on right.	X-ray available shows hip not reduced. Patient could not be found. AGE 180°, AGF 70°, abduction 35°.
	5	M. H.	F.	7	L.	6-23-22	R. W.	Reaming.	Walks with slight limp. Head above site of original acetabulum. RA** 30", LA 29", AGE 180°, AGF 160°. Stable hip.
1923	6	H. G.	F.	14	L.	2-26-23	S. K.	Reaming.	Not reduced to level of original acetabulum. Stable hip. AGE 180°, AGF 130°.
	7	R. N.	F.	13	Bil.	L. 3-26-23	S. K.	Reaming and remodelling head. Right not operated on.	Ankylosed.
	8	H. F.	M.	7	L.	4-2-23	R. W.	Reaming.	Some pain in hip in wet weather. Walks quite well, few degrees only of motion. AGE 170°. Limb rotates outward RA 33¼", LA 32¾".
	9	L. N.	F.	9½	Bil.	L. 6-4-23	R. W.	Reaming. Right by closed reduction.	Head above level of old acetabulum. Stable, painless hip, about 10° motion in all directions.
	10	M. K.	F.	13	R.	12-3-23	R. W.	Reaming.	Ankylosed in 125° flexion, 15° abduction. Patient walks very awkwardly. Readmission advised.
1924	11	C. F.	F.	8	Bil.	L. 1-21-24	S. K.	Reaming. Closed reduction, right.	Walks with limp on left, not reduced at last exam. Not able to trace patient.

TABLE I — CASES REVIEWED — *Continued*

Year	*Case No.*	*Name*	*Sex*	*Age*	*Hip*	*Date of Operation*	*Operator*	*Type of Operation*	*Follow-up Records*
1924	12	E. J.	F.	11	R.	4-28-24	R. W.	Reaming.	Walks well. AGE 165°, AGF 135°.
	13	R. M.	F.	12	R.	4-23-24	A. W.	Shelf.	Head above old acetabulum, stable hip. No recent notes.
	14	M. F.	F.	3	L.	9-22-24	R. W.	Reaming.	Unable to trace patient since removal of plaster. At that time head was at site of original acetabulum.
	15	E. K.	F.	6	R.	11-3-24	R. W.	Reaming.	Head was at site of original acetabulum 2 mos. after operation. No follow-up notes available.
	16	G. B.	F.	8	L.	5-26-24	R. W.	Reaming and shelf.	Walks with limp. AGE 140°, AGF 135°, fixed adduction about 10°.
	17	M. deM.	F.	6	L.	8-11-24	R. W.	Reaming.	Head at site of original acetabulum; hip fixed in 160° flexion. Walks well.
	18	A. R.	F.	9	L.	11-22-24	R. W.	Reaming.	Head at site of original acetabulum. AGE 180°, AGF 140°, abduction 15°, RA = LA.
	19	H. S.	F.	8	Bil.	L. 5-1-25 R. 12-15-24	R. W.	Lorenz bifurcation on both hips.	Waddle and ability to abduct distinctly improved. R. AGE 180°, AGF 90°. L. AGE 180°, AGF 135°.
	20	M. M.	F.	4	R.	12-8-24 3-24-30	R. W. S. K.	Reaming. Lorenz bifurcation.	Walks well, wearing 1″ raise in right shoe. Stable, painless hip. AGE 180°, AGF 160°. Some fixed abduction; movement from 15–30° in abduction.
1925	21	C. D.	F.	25	L.	6-1-25	R. W.	Bifurcation.	No recent note. Unable to find patient.
	22	A. L.	F.	13	L.	1-2-25	I. B.	Reaming.	AGE 180°, AGF 115°, head above old acetabulum.
	23	R. P.	M.	10	R.	5-11-25	R. W.	Replacement.	Head redislocated. No recent note. Wearing raised shoe when last seen.

TABLE I—CASES REVIEWED—*Continued*

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1925	24	E. C.	F.	12	R.	7-19-26	A. W.	Shelf.	Walks with marked limp. Head just above site of old acetabulum. AGE 180°, AGF 80°, abduction from 0-20°.
	25	F. G.	F.	25	R.	11-22-26 4-4-27	R. W. S. K.	Bifurcation, Reconstruction.	Walking with limp in about 20° abduction. AGE 180°, AGF 160°.
1926	26	H. Z.	F.	12	Bil.	3-29-26	R. W.	Lorenz bifurcation. Right not operated upon.	Walks quite well. Stable hip on left. AGE 180°, AGF 120°, abduction 0-30°.
1927	27	J. P.	M.	9	R.	1-24-27	S. K.	Reaming.	Hip in fixed abduction about 10°. AGE 180°, AGF 150°. Wearing raised shoe.
	28	J. S.	M.	7	L.	1-31-27	S. K.	Reaming.	Walks well, hip presents a few degrees of motion.
	29	E. R.	F.	9	L.	3-3-27	P. C.	Reaming, not pulled down.	Head above old acetabulum. Painless, stable hip. AGE 160°, AGF 130°.
	30	R. Z.	F.	12	L.	9-6-27	A. W.	Shelf.	Walks well, shelf above original acetabulum. Wearing cork wedge in shoe, stability and mobility assured. AGE 180°, AGF 90°, abduction 0-15°. Walks with limp.
	31	M. F.	F.	15	L.	9-6-27	A. W.	Reaming and shelf.	Hip ankylosed in fair position. Walks well.
	32	C. S.	F.	4	Bil.	R. 12-19-27 L. 12-9-28	A. K.	Replacement.	Redislocation occurred. Patient did not return and cannot be traced.
	33	W. L.	M.	11½	Bil.	R. 6-13-27	R. W.	Bifurcation. L. not opened.	Walks awkwardly, but has no pain. R. AGE 180°, AGF 90°, abduction 0-15°. Operation considered very satisfactory.
1928	34	C. W.	F.	4	L.	1-23-28	S. K.	Reaming.	Head in original acetabulum. Readmitted for flexion adduction deformity of hip.

TABLE I — CASES REVIEWED — *Continued*

Year	*Case No.*	*Name*	*Sex*	*Age*	*Hip*	*Date of Operation*	*Operator*	*Type of Operation*	*Follow-up Records*
1928	35	F. M.	F.	5	R.	Feb. 1928	P. C.	Shelf.	Result poor, walks awkwardly, very little motion.
	36	L. R.	M.	5	L.	9-11-28	A. W.	Shelf.	Good range of motion in all directions. Stable hip, head slightly above acetabulum.
	37	G. B.	M.	4½	Bil.	R. 7-2-28	A. K.	R., reaming and shelf. L., closed reduction.	R. hip slipped, postoperatively. AGE 180°, AGF 90°. Unstable hip with marked lurch.
	38	J. S.	F.	8	Bil.	L. 9-17-28 R. 1-7-29	A. W.	L., reaming not reduced. L. bifurcation 11-5-28. R. bifurcation 1-7-29.	Painless, stable hip. R. AGE 180°, AGF 110°, abduction 10-25°. Left head felt anterior bifurcation, almost disappeared. (See recent x-ray.)
	39	R. S.	F.	3	Bil.	R. 11-22-28	R. W.	Reaming on right. Left closed reduction.	Stable hip, very little motion on right.
1929	40	O. O.	F.	6	R.	5-16-29	P. C.	Shelf.	Walks with limp. Head above original acetabulum. Stable hip. AGE 180°, AGF 90°, abduction 0-35°.
	41	H. L.	F.	5½	Bil.	L. 4-15-29	R. W.	L., reaming. R., closed.	Gait improved. Stable hip.
	42	H. K.	M.	7	L.	10-28-29	R. W.	Reaming, using reconstruction approach.	Excellent stability and fair range movement. Head at site of original acetabulum.
	43	E. A.	M.	6	R.	July 1929	P. C.	Replaced—osteotomy to correct torsion.	Walks well, slipped anteriorly. AGE 180°, AGF 90°.
	44	D. C.	F.	10	R.	Mar. 1929	P. C.	Replacement — osteotomy to correct torsion.	Excellent range of movement, all directions. AGE 180°, AGF 80°, abduction full range.
	45	I. M.	F.	8	Bil.	Apr. and Aug. 1929	P. C.	Replacement.	Reported that hips redislocated. Not seen recently.
	46	M. V.	M.	10	L.	May 1929	P. C.	Replacement.	Infection with dislocation of head. Ankylosis resulted.

TABLE I — CASES REVIEWED — *Concluded*

Year	Case No.	Name	Sex	Age	Hip	Date of Operation	Operator	Type of Operation	Follow-up Records
1930	47	M. R.	F.	11	L.	Jan. 1930	P. C.	Reaming and shelf.	Flexion adduction deformity developed, no motion. Walks awkwardly.
	48	P. S.	M.	6	Bil.	R. Jan. 10, 1930 L. July 30, 1930	P. C.	R., reaming. L., transplanting capsule down and reaming.	Walks awkwardly, lordosis and waddle. R. AGE 180°, AGF 160°. L. AGE 180°, AGF 170°.
	49	H. K.	F.	12	R.	July 1930	P. C.	Transplantation of capsule, reaming.	Barely perceptible limp. Head at site of old acetabulum. Trace motion in all directions. Stable hip.
	50	E. C.	M.	7	Bil.	Oct. 10, 1930 Dec. 15, 1930	P. C.	Reaming type, both sides.	Patient presented marked general muscular relaxation. Reduction easily effected. No recent reports.
	51	G. W.	F.	5	Bil.	R. July 2, 1930 L. Nov. 10, 1930	P. C.	Transplantation of capsule with reaming acetabulum.	R. AGE 180°, AGF 130°. L. AGE 180°, AGF 100°. Abduction 0-15°, both hips well reduced.
	52	A. C.	F.	22	R.	Dec. 20, 1930	P. C.	Shelf.	Hip became infected. Patient had 4+ Wassermann. AGE 170°, AGF 150°, adduction 10°.
	53	R. N.	M.	4	L.	3-3-30	A. K.	Reaming type. Hip redislocated, being converted into anterior transposition.	Good range of motion in all directions. Gait improved.
	54	J. S.	F.	9	Bil.	L. 2-4-30 R. 6-6-30	A. W.	Shelf.	X-ray shows satisfactory shelf. Patient walks awkwardly, but waddle corrected.
	55	D. Mc.	F.	11	L.	9-29-30	A. W.	Reaming and shelf.	Head above site of original acetabulum. AGE 180°, AGF 140°, abduction 0-15°.
	56	P. G.	F.	3	Bil.	R. 11-24-30 L. 12-10-30	A. W.	Reaming.	Right hip quite stable, left only partially. AGE 180°, AGF 90°, both sides.

*AGE—Angle of greatest extension. †AGF—Angle of greatest flexion.
**Distance from anterior superior spine to internal malleolus; on right, RA; on left, LA.

TABLE II

SUMMARY

Total number of hips operated upon	66	*Ages*	
Total number of patients	56	3 years to 25 years	
Unilateral (right)	15		
Unilateral (left)	22	Males	14
Bilateral	19	Females	42

Types of operation employed.

1. Replacement—after cutting contracted capsule, etc.	7 Hips
2. Reamed-out acetabulum made at or near original site	31 Hips
3. Some type of osteoplastic buttress	8 Hips
4. Combination of 2 and 3	5 Hips
5. Anterior transposition	4 Hips
6. Lorenz bifurcation	8 Hips
7. Capsule about head transplanted into reamed-out acetabulum	4 Hips

SUMMARY

In summarizing these cases one may say that the age is largely a factor in determining the type of operation employed, but that usually in any type employed with children between three and ten years of age the patient should be given preliminary treatment. A thorough stretching of the muscles about the hip, tenotomy of the adductors, and traction have been found of value. The reaming type will insure stability but in general very little mobility. The osteoplastic buttress type usually prevents further upward displacement of the femur but, unless care is taken to restore the backward position of the dislocation, the characteristic gait is only partially corrected. However, it is an operation that usually assures stability and a satisfactory degree of mobility. In the frankly irreducible case, the Lorenz bifurcation is a most valuable procedure. It renders the hip stable and gives a surprising degree of mobility. It is of particular value in the adult bilateral case with pain. In the unilateral case it has the disadvantage of shortening an already short extremity, even though the characteristic lurch and lordosis become less.

The last method presented—that of preserving the natural synovial sac over the head of the femur, and transplanting it into a reamed-out acetabulum at or near the original acetabulum—is an attempt to assure a genuine reduction of the dislocation, plus the preservation of stability and mobility. To date four hips have been operated upon by this method and the results have been encouraging.

Acknowledgment is here made to the other members of the First Division who have kindly permitted this ten-year review of the open operation for congenital dislocation of the hip.

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CONGENITAL DISLOCATION OF HIP TREATED BY OPEN OPERATION

A Report of Seventy-two Cases*

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A detailed study of all patients treated at the New York Orthopaedic Hospital for congenital dislocation of the hip by open operation between January 1920 and July 1929 has been made. In all but two of the cases of congenital dislocation of the hip treated before 1920 a closed reduction was used, and an end-result study of this series, through October 1920, has been published.† A study of the closed operations done since that time will be undertaken shortly for further comparison with the open reduction.

This group includes seventy-two cases. Open operation being now a well established procedure, our effort will be to indicate what types of cases are more suitable for open than closed operation, what type operation should be done in different kinds of hips, and what results may reasonably be expected. The first portion of this presentation will be devoted to a study of the cases operated upon and the operation itself; in the last part the results of the operations will be taken up.

THE CASES

Age at operation

The oldest patient was twenty years of age, the youngest one and one-half years, the average four and three-quarters years. Sixteen cases (twenty-two per cent.) were less than three years old, thirty-nine (fifty-four per cent.) from three to five years inclusive, fourteen (twenty per cent.) from six to nine years, and three (four per cent.) above ten years.

Hip involved

In forty-six cases (sixty-four per cent.) one hip was involved; in twenty-six both. Of the latter, sixteen had one hip treated by closed reduction only, so that there were only ten double open reductions, making a total of eighty-two hips.

*Read before the Section on Orthopedic Surgery, New York Academy of Medicine, October 16, 1931.

†Congenital Dislocation of the Hip. A Report of 310 Cases Treated at New York Orthopaedic Dispensary and Hospital. By B. P. Farrell, H. L. vonLackum, and A. deF. Smith. J. Bone and Joint Surg., VIII, 551, July 1926.

Type of dislocation

All of the dislocations were anterosuperior. Seven per cent. of the hips were only subluxated (femoral head not beyond or above the superior acetabular margin), and ninety-three per cent. were completely dislocated. Of the latter, the inferior margin of the head was displaced above the superior margin of the acetabulum in thirty-one per cent., so that the head was three-quarters of an inch or more above the acetabulum.

Anteversion

As this deformity is considered to be an important factor in redislocation, regardless of whether it is instrumental in causing the original dislocation or not, its amount was carefully noted clinically and at operation and estimated by comparative roentgenograms. In sixteen hips (twenty per cent.) the anteversion was more than sixty degrees, in thirty-one (thirty-eight per cent.) between forty-six and sixty degrees, in twenty (twenty-four per cent.) between thirty and forty-five degrees, and in fifteen (eighteen per cent.) less than thirty degrees. In fifteen of the sixteen hips under three years of age there were forty degrees or more of anteversion, indicating that the anteversion probably develops in infancy, if not before birth. The average torsion for cases under three years was fifty-eight degrees, an average greater than that for the whole series.

Roentgenograms

In judging the different types of hips for determining the choice of treatment and the likelihood of success the following were noted:

Acetabulum.—Degree of obliquity of the roof, the presence and extent of a groove at the superior margin, and the depth of the acetabulum.

Extent of the dislocation.

Anteversion.—Estimated roughly by comparison of roentgenograms with knees forward and with knees internally rotated.

Relaxation.—It was found that the above observations did not give a complete picture of the condition at the hip, so at present roentgenograms are also being taken standing (or with upward pressure if the child is too young to stand) and with manual traction in order to get an idea of how unstable the hip is and of how difficult it will be to bring the head down to the acetabulum.

Closed reductions preceding open operation

In forty-six of the eighty-two hips (fifty-six per cent.) one to five attempts at closed reduction had been made previous to the open operation. The longest interval between closed and open operations was five years, the shortest a few minutes; in twenty hips attempts had been made within two weeks. In five of the hips the attempts had been made at other hospitals. In twenty-one of the remaining forty-one hips the attempts were completely unsuccessful; in twenty some measure of apparent reduction was accomplished but redislocation occurred shortly after

plaster removal several months later. From a study of the operative findings in these forty-six hips, it is evident that in most of them the head had been placed opposite or in front of the acetabulum but had never passed through the constriction in the capsule or labrum glenoidale. At operation, reduction before enlargement of the capsule was found to be impossible in twenty-eight hips (sixty-one per cent.). In twenty of these forty-one hips a shallow acetabulum with very oblique roof indicated that redislocation would have been likely, and this was borne out by the facts that ten of these hips had been left in casts for an average of six months following closed reduction but had come out on removal of the cast; and attempts at closed reduction of the other ten had failed to get reduction stable enough to justify continuance of immobilization. In four hips the ligamentum teres was so large that its size alone would have prevented reduction. Thirty-six hips had had no attempt at closed reduction; at operation the head could be passed readily into the acetabulum in only five, but of these two required removal of a large ligamentum teres.

The operation

No preliminary traction was used in any case. The Smith-Petersen approach was used throughout. Usually the anterosuperior half of the capsule was divided parallel and close to the acetabulum. The constriction in the capsule was divided inferiorly (thirty-four hips) and the labrum glenoidale cut (twelve hips) where necessary for reduction. The ligamentum teres was removed when large enough to prevent reduction or too elongated to be of any value (thirty-five hips). It was necessary to cut the adductor tendons in three hips.

The treatment of the acetabulum varied and will be described in three groups:

1. Simple reduction, fifty-four per cent. (a) Only the pad of fat or fibrous tissue removed from the acetabulum, seventeen hips (twenty-one per cent.). (b) Acetabulum left undisturbed, twenty-seven hips (thirty-three per cent.).

2. Gouged, forty-two per cent. (a) Cartilage removed from the acetabulum to deepen or round the cavity sufficiently to permit good socketing of the head in the shallow or oblique types. This was done in eighteen hips (twenty-two per cent.). (b) Gouging deepened to expose or include some bone because removal of cartilage alone was insufficient, or because the head would not come down to the acetabulum which had to be enlarged upward. This was done in sixteen hips (twenty per cent.).

3. Shelf, eleven per cent. A shelf built over the head after reduction by turning a slab of bone down from the ilium and blocking it out with smaller slabs or chips. This was done in nine hips, six of which were also gouged.

In two of the hips the head was trimmed because of a large irregular projection of cartilage, and in one hip a projection of neck inferiorly was removed.

Usually the capsule was approximated by tying the stay sutures inserted when it was opened; in only three cases was the capsule plicated.

Pathological findings at operation. (Note: As all of the facts were not recorded in every case, the totals are variable.)

Acetabulum.—Thirty acetabula were shallow, ten filled with fibrous tissue and four with fat; twenty formed good sockets. Of the sixteen hips with "good" sockets seen in 1930 eight have remained in, three of which were gouged and four of which had anteversion corrected; six of the remaining hips subluxated, only one of which had anteversion corrected; and two dislocated, neither having had anteversion corrected. None of the latter eight hips was gouged. In each group of eight hips anteversion was forty degrees or more in all but one hip. These findings suggest that correction of anteversion is important even with a good socket if this deformity is sufficient to be a factor in redislocation (more than forty degrees).

Ligamentum teres.—This ligament was absent in five hips (three of which had had a closed reduction), ruptured in two (both closed reductions), and thin or frayed in seven (three closed reductions). In none of these fourteen hips was coxa plana present. The femoral head was irregular in two of the seven hips with a thin ligamentum teres, but in none of those in which the ligament was absent or ruptured. Free bleeding occurred from only one of the thirty-nine teres ligaments removed or cut at operation, this patient being the youngest in the series (age one and one-half years). Slight bleeding occurred in four instances (ages three to six and one-half).

Capsule.—The capsule and labrum glenoidale were found constricted or the inferior portion pulled up over the lower half of the acetabulum and usually adherent, thus interfering with reduction in fifty-six hips. In eight hips neither of these abnormalities was present. No notation was made about the remainder. The average age of children with constricted capsules and those with the capsule pulled up over the acetabulum inferiorly was no greater than the average of the remainder. There were relatively just as many hips with these abnormalities in the group under three years, including the patient one and one-half years old, as in the cases above three years.

Femoral head.—The cartilage was found partially loose or recently damaged in six hips. In one hip there was a displaced epiphysis and in another a hemarthrosis. These eight patients had recently had attempts at closed reduction. Thus there is an incidence of forty per cent. of definite severe traumatisms inside the joint in the twenty hips having the hip opened within two weeks of manipulation.

Other Operations

More than one operation.—Five hips required two operations, one required three. Five of the six had poor acetabular roofs at the first operation. At the second operation four of the hips were gouged, and the

one requiring three operations was gouged to bone the last time. Anteversion in these six hips varied from forty to sixty degrees and was corrected in five. The non-gouged hips and one of the four gouged have subluxated, and the remaining three remain in. It will be seen that a second operation is no more apt to succeed than the first unless the socket is deepened sufficiently and excessive anteversion corrected.

Closed reductions for redislocation after open reductions.—This procedure was successful in one of the two hips for which it was used.

Manipulation for better position.—Manipulations were done on four hips to secure better socketing, the head being subluxated into the upper half of the acetabulum in each instance. Subluxation recurred in every instance, one hip later dislocating entirely.

Osteotomy for anteversion.—This operation was done in thirty-eight hips, none with less than forty degrees of anteversion, nineteen (fifty per cent.) having sixty degrees or more, the average being fifty-eight degrees. A pin was driven through the shaft just below the greater trochanter to maintain internal rotation of the upper fragment, a subperiosteal transverse osteotomy done a short distance above the femoral condyles, and the lower fragment rotated externally enough to correct the deformity. Excellent correction (to twenty degrees or less) was obtained in twenty-three (sixty per cent.), good correction (to thirty degrees or less) in thirty-three (eighty-seven per cent.), and slight overcorrection in one hip. In the group of sixteen patients under three years old, five hips had correction of anteversion.

Complications

Deaths.—One patient died on the operating table. Thus, including the bilateral cases, those with more than one operation, and the osteotomies, there was one death in one hundred and thirty operations (eight-tenths of one per cent.).

Infections.—There were two trivial superficial infections. The joint did not become infected in any hip.

Postoperative care

Plaster hip spicas were applied just after operation in all cases, usually in a position of extension, abduction of about thirty degrees, and internal rotation. The spicas were worn for an average period of three months, varying from six weeks to ten months. In a few cases the spica was changed once or more during this period and the abduction reduced.

Massage.—Massage and active and passive exercises were used in most instances for a few days after removal of plaster, and if the hip remained somewhat stiff they were continued for several weeks.

Periods of stiffnesss following operation.—Nearly half of the hips regained more than seventy-five per cent. of their motion within the first eight months after operation. This group includes a slightly larger proportion of the younger cases, but also includes about thirty-five per cent. of

the hips that were gouged and many patients wearing casts three months or longer. Only a few hips gained motion of consequence after being stiff more than a year; the majority of these had been gouged to bone and were over five years old.

Time of redislocation.—Redislocation or subluxation never occurred except within a few months after operation and usually followed plaster removal or walking. Roentgenograms with the child standing are particularly valuable during the period just after immobilization. The joint space may appear wide before weight-bearing, and the femoral head move upward on standing. Such hips require further recumbency and close observation.

Results after operation

The remainder of the report will be devoted to a study of the patients who were available in 1930 for examination. Sixty-two of the seventy-two patients were seen, including the ten with bilateral open operations, making a total of seventy-two hips. The longest period between operation and last examination was eleven years, the shortest one and one-half years, and the average four years.

A careful history was taken to determine how far patients could walk without fatigue and to what extent they could participate in athletics, as it is important in a true evaluation of results not only to find out which patients are able to get about without pain but to compare them accurately with normal children. Roentgenograms were made in all cases to determine the anatomical result, and the hips showing any tendency to subluxation were also roentgenographed standing and with traction to show the effect of weight-bearing and the amount of relaxation.

A hip with a moderately wide joint space or displaced upward, but not beyond the superior acetabular margin on weight-bearing, was classified as subluxated.

ANATOMICAL RESULTS

The anatomical results, classified as to type of operation, are summarized in Table I, and the results in the different age groups are given in Table II.

The hips which were gouged show a much better record for maintenance of reduction than the simple reductions. The better percentage for the group in which only cartilage was removed is probably due to the fact that these hips were anatomically more favorable at the beginning than the group requiring gouging to bone. Maintenance of reduction diminishes directly with age at operation.

Attempts have been made to judge the sufficiency of the acetabulum in the preoperative roentgenogram. We tried to correlate such determinations on these hips with the results of simple open reductions (Table III). In the table the evaluations are based on the depth of the acetabulum and the obliquity of the roof as seen in the preoperative roentgenogram. The

TABLE I

ANATOMICAL RESULTS

Procedure	*Result*					
	Reduced		*Subluxated*		*Redislocated*	
	Hips	*Per cent.*	*Hips*	*Per cent.*	*Hips*	*Per cent.*
Simple reduction*	20	48	17	40	5	12
Acetabular cartilage gouged**	14	82	3	18	0	0
Acetabulum gouged to bone***	10	77	2	15	1	8
Totals	44	61	22	31	6	8
Shelf stabilization	6	75	2	25	0	0

*Including three of the stabilizations (two reduced, one subluxated).
**Including four of the stabilizations (three reduced, one sudluxated).
***Including one of the stabilizations (reduced).

TABLE II

ANATOMICAL RESULTS GROUPED AS TO AGE

Age	*Reduced*		*Subluxated*		*Redislocated*	
	Hips	*Per cent.*	*Hips*	*Per cent.*	*Hips*	*Per cent.*
Under three years	9	75	3	25	0	0
Three to five years	28	65	12	28	3	7
Six to nine years	8	57	3	21.5	3	21.5
Ten years or over	1	33	2	67	0	0

number of cases in each group is too small to justify detailed conclusions but it seems fair to say that such determinations of the sufficiency of the acetabulum are practically valueless. In older children, with little cartilage on the head or in the acetabulum, a better estimate can be made, particularly if the head appears in the roentgenogram to be apposed to the bony superior acetabular margin, in which case there can be no cartilaginous superior lip and the roof must be deficient.

TABLE III

Correlation Between Acetabulum as Seen in Roentgenogram and Result in Simple Reductions

	Reduced		*Subluxated*		*Redislocated*	
	Hips	*Per cent.*	*Hips*	*Per cent.*	*Hips*	*Per cent.*
Acetabular roof						
Good	3	38	4	50	1	12
Fair	2	40	2	40	1	20
Poor	10	72	3	21	1	7
Very poor	1	50	1	50		

TABLE IV

Residual Symptoms

Symptoms	*Patients*
Pain or ache	6
Fatigue	18
Limp noticed by patient	7
Stiffness	4
Partial incapacity for athletics	10
Number of patients having symptoms	25

TABLE V

Relation of Symptoms to Anatomical Result and to Gouging

Result	*Symptoms present*		*No symptoms*	
Reduced	13	33%	26	67%
Subluxated	7	41%	10	59%
Redislocated	5	83%	1	17%
Simple reduction	13	41%	19	59%
Cartilage gouged	4	23%	13	77%
Gouged to bone	8	61%	5	39%

SYMPTOMATIC RESULTS

The symptomatic results are given in Tables IV and V.

Thus twenty-five of sixty-two patients (forty per cent.) had symptoms. Symptoms were much more frequent in the hips which redislocated and in those gouged to bone. Age seemed to be only a minor factor.

FUNCTIONAL RESULTS

The relation of limp and telescoping to the result is given in Table VI and of shortening in Table VII.

The frequency of limp and of telescoping increased greatly in the groups which did not remain reduced, as seen in Table VI. Hips which remained reduced rarely telescoped; the same is true for the hips gouged.

TABLE VI

LIMP AND TELESCOPING

		Reduced	*Subluxated*	*Redislocated*	*Total*	*Cases*
Limp (patients)	Slight	19	9	3	31	76%
	Moderate	4	2	1	7	17%
	Severe		1	2	3	7%
	Total:					
	Limp	23 (59%)	12 (71%)	6 (100%)	41	66%
	No limp	16 (41%)	5 (29%)		21	34%
Telescoping (hips)	Slight	3	5	2	10	55%
	Moderate	1	5	2	8	45%
	Total:					
	Telescoping	4 (9%)	10 (53%)	4 (67%)	18	25%
	No telescoping	43 (91%)	9 (47%)	2 (33%)	54	75%

TABLE VII

SHORTENING—SINGLE HIPS ONLY

	Reduced	*Subluxated*	*Redislocated*
Shortening	10. Average 0.5″	9. Average 0.5″	3. Average 1.2″
No shortening	16	2	0

As would be expected, the frequency and amount of shortening are greater with redislocation. Gouging cannot be blamed for shortening in the ten cases which remained reduced as only three were gouged.

TABLE VIII

LIMITATION OF MOTION

	Hips	Per cent.	Cartilage gouged	Gouged to bone	Subluxated	Redislocated	Previous closed reduction	Limitation before operation
Flexion deformity	16	22	2	4	5	2		2
Flexion of less than 120°	32	44	7	8	11	4	12	3
Flexion of less than 90°	15	21	2	5				
Flexion of less than 60°	6	8	1	3				
Abduction of less than 30°	33	46	6	7	7	5	8	14
Abduction of less than 10°	7	10	0	2				
Adduction deformity	2	3	0	0				
Rotation less than 75°	32	44	5	10	7	4	13	8
Rotation less than 45°	17	23	1	5				
Rotation less than 30°	8	12	0	3				

N.B.—As adduction was limited only in the very stiff hips it is omitted from this table. The figures denote the number of hips in each instance.

The results as to individual motions are given in Table VIII, and of all motions in Table X.

As there is no accepted standard of evaluating the total motion in a hip we express this motion by means of an index. If each motion of the hip be arbitrarily evaluated for its importance in function, the index will be obtained by multiplying the degrees of each motion by its arbitrary constant and adding these sums (Table IX). The constants we have used are:

For flexion and abduction 0.4
For adduction and internal rotation 0.2
For external rotation and extension 0.1

TABLE IX

EXAMPLE OF INDEX OF MOTION

	Degrees of motion	*Constant*	*Product*
Flexion	145	0.4	58
Abduction	45	0.4	18
Adduction	30	0.2	6
Internal rotation	30	0.2	6
External rotation	60	0.1	6
Extension	10	0.1	1
Index of motion			95

Reconciliation of index with terms used in the literature:

Hypermobile	over 110	Fair	45 to 60
Normal	90 to 110	Poor	30 to 45
Good	60 to 90	Bad	under 30

Using this method for evaluating the total motion in these hips, the result may be expressed as in Table X.

TABLE X

TOTAL RANGE OF MOTION, EXPRESSED AS THE INDEX

Type of reduction	*Reduced*		*Subluxated*		*Redislocated*	
	Average	*Range*	*Average*	*Range*	*Average*	*Range*
Simple	78	23–96	71	29–95	65	52–86
Cartilage gouged	87	42–109			65*	
Gouged to bone	62	17–96	62	12–96	63*	

*Three cases or less.

Summarizing the results as to range of motion, we find that in the entire group the motion is good or normal in eighty per cent. of the hips and bad in only eight per cent.; that the range of motion in the group in which gouging of cartilage only was done is better on the average than for the simple reductions; and the group gouged to expose bone averages a little worse than the simple reductions. The latter group, however, includes several cases in which an entire new socket was gouged out of bone and shows a better maintenance of reduction than the simple reductions. The

best average motion occurred in the group in which reduction was maintained, there being little difference between the subluxated and redislocated groups. The stiff hips in the gouged group usually were in plaster more than three months; we have since found that so long a time is not necessary, and, as the immobilization increases the stiffness, consider it inadvisable. All of the moderately stiff hips remained well socketed.

The shelf operation

The number of cases is too small for detailed conclusions. The average index of motion is 73, which compares favorably with the other groups. Subluxation occurred in two of the eight hips.

Anteversion

The results of reduction in cases having an osteotomy for correction of anteversion are given in Table XI.

TABLE XI

OSTEOTOMY FOR ANTEVERSION

	Reduced		*Subluxated*		*Redislocated*	
	Hips	*Per cent.*	*Hips*	*Per cent.*	*Hips*	*Per cent.*
All hips having osteotomy	24	63	12	32	2	5
Simple reduction and osteotomy	10	48	10	48	1	4
Gouged reduction and osteotomy	14	82	2	12	1	6
No osteotomy, anteversion 30° or more	7	44	6	38	3	18

Thus, cases having osteotomy for correction of anteversion presented a lower average for redislocation. However, unless the acetabulum is a good socket, correction of anteversion without gouging is often not sufficient to maintain reduction.

Coxa plana

All hips with irregular ossification in the femoral head accompanied by flattening were classified as having coxa plana. Coxa plana occurred in fourteen hips after open operation. It was present in three hips before operation and increased slightly afterward in two of these; these three hips had previously had closed operations, in one instance the femoral neck having been fractured. Roentgenograms were not available long enough postoperatively to establish the occurrence of coxa plana in eight hips of the series; in the remaining sixty-four hips the incidence was twenty-five per cent. The age at onset was one and one-half to five and one-half years, the

average being three and one-half years. The first evidence of the condition appeared in from two to twelve months after operation, the average interval being six and one-half months. Progression continued for an average of one and one-half years, and the average time before the process became quiescent was two years. No relation was found between the postoperative interval before onset or the period of progress and the age at operation. At the last examination eight of these hips were still in place, seven were subluxated and one was redislocated; thus there was a higher relative incidence of coxa plana in the hips which did not remain in. Only six of the hips were gouged (three to bone), the incidence in the gouged hips being twenty per cent., slightly lower than that for the whole group. The two hips in which the head was trimmed, and the one in which the neck was fractured at previous closed operation, developed coxa plana. Five of the hips had had closed operations with long immobilization; five hips had had attempts at closed reduction and in one of these the cartilage of the femoral head was found damaged at later operation. The ligamentum teres was excised at operation in eight of these hips and it was absent in one hip; thus coxa plana was no more frequent in these cases than in the group as a whole. At operation the femoral head was found to be irregular in five hips of this group. Six hips had an osteotomy for anteversion. The hips were left in plaster from one and one-half to ten months, average three and one-half months; only three wore plaster more than three months. Coxa plana was mild in degree in three hips, moderate in five, and marked in eight. At the last examination there were symptoms in six of the hips with coxa plana but the process was quiescent roentgenographically in five of these and the symptoms were similar to those of hips without coxa plana. Motion was moderately limited in four hips, slightly in eight, which was no worse than for the remainder of the congenital hips. Coxa plana was present in two of the hips which had only closed operations, whereas the opposite hips, having open operations, included only one case of coxa plana.

The cause of the coxa plana in these hips appears to be a vascular disturbance in the tissues about the femoral neck due to pressure or inflammation (traumatic), secondarily affecting the circulation to the head, but this will be discussed further in a separate paper on coxa plana.

Results of closed reduction

Of the sixteen hips having only a closed reduction on one side, nine remained reduced, five subluxated and two redislocated, compared to nine, four, and three, respectively, for the open reductions on the opposite side. The examinations were made from two to thirteen years afterwards (average six years). Limp and fatigue were present in eight, moderate stiffness in two, and telescoping in three of the closed reductions. Closed operations had failed to reduce the dislocation in fourteen of the sixteen opposite hips which had open reductions, and closed reduction of the other two hips was obviously impossible.

SUMMARY AND DISCUSSION

A study of eighty-two open reductions of congenital dislocation of the hip, with a follow-up examination of seventy-two of the hips, is presented, with details of the preoperative examination and treatment, the operative findings and procedure, postoperative care, and the results several years after operation. It is definitely shown that a fairly large percentage of congenital dislocations of the hip cannot be reduced, or the reduction maintained, by closed operation because of anatomical abnormalities about the acetabulum. It is further demonstrated that roentgenograms taken with the patient standing and under traction, as well as the ordinary recumbent views, are essential for a thorough study of these hips both before and after operation. It is particularly important that the pathological condition and mechanism at the hip be carefully studied at operation. It is our practice now to study the hip at operation upon exposure of the capsule, after opening the capsule, and after removing the ligamentum teres, to determine the factors interfering with reducton and stability, and we test the stability of the hip after reduction with upward pressure on the leg during gradual adduction and in various positions of rotation. The rotation procedure is valuable in determining the necessity for correction of anteversion. Furthermore, there is so much individual variation in these hips that they cannot be grouped together indiscriminately and compared superficially in attempts to present the best apparent results. It is felt that a more definite method of comparison is required for properly evaluating the results of the operation than the usual "excellent", "good", or "fair" ("poor" rarely appears in the literature) and, for want of an accepted standard, our cases are reported in some detail and a method of evaluating motion given.

CONCLUSIONS

1. Closed reduction is the treatment of choice in congenital dislocation of the hip when a stable complete reducton can be obtained by this method without much traumatism. It is not often possible to recognize such a hip clinically or by roentgenogram, but it is uncommon after the age of three years.

2. Attempts at closed reduction frequently fail, either primarily or secondarily. Repeated manipulations are rarely successful and often result in considerable damage to the hip.

3. The chief causes of failure of closed procedure are the obstructions offered by the constricted capsule and labrum glenoidale and the redundant ligamentum teres. When either of these obstructions is present open reduction is indicated, with division of the constrictions inferiorly and removal of the ligamentum teres.

4. A shallow acetabulum with an oblique roof frequently permits redislocation. Open reduction, with deepening of the acetabulum, is advisable for this type of hip. If exposure of much bone would be required, a shelf operation is preferable.

5. Open reduction is almost always successful primarily. Proper selection of methods to gain stability—removal of the ligamentum teres, gouging, shelf stabilization, correction of anteversion, removal of the projection at the junction of the head and neck inferiorly, shortening of the capsule anteriorly—is most important. When redislocation occurs, it is usually shortly after plaster removal and the hip should be carefully watched at this time, with particular attention to roentgenograms in the standing position. Secondary manipulations to improve the reduction have been of little value.

6. The shelf operation results in less stiffening than does gouging a new socket out of bone and is therefore preferable when the femoral head cannot be brought down to the level of the acetabulum or when the socket is so shallow or oblique that maintenance of reduction, even with gouging of some cartilage, is hopeless.

7. Correction of anteversion is usually advisable when the deformity is forty-five degrees or more unless a shelf operation is done. There is some evidence that spontaneous correction may occur over a period of years if the hip remains reduced, but in the meantime some hips will have redislocated, an outcome which could have been prevented by an osteotomy.

8. Reduction was maintained in sixty-one per cent. of the hips at examination eighteen months or more after operation, subluxation occurred in thirty-one per cent., and only eight per cent. redislocated. A good functional result was obtained in sixty-seven per cent. of the hips.

9. Fatigue, disability for athletics, limp, and limitation of motion were frequent residual symptoms after open reduction in the hips which had redislocated and in those gouged to bone. Stiffness after operation usually disappears in six months or less, but if present after eighteen months is likely to persist indefinitely.

10. Cox plana is not infrequent after reductions in congenital dislocation of the hip, but seems to be unrelated to damage to, or removal of, the ligamentum teres, maintenance of reduction, or type of operation.

PERTHES' DISEASE*

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Perthes' disease, the subject of this report, is now an established clinical entity with a growing literature. Coxa plana, the end result of Perthes' disease, is here regarded as a dysarthrosis of the hip joint, exhibiting an increase in stability with a decrease in range of motion in the joint.

The purpose of this report is: (1) to present the record of an unusual case of Perthes' disease with roentgenograms; (2) to stress an intermediate type of deformity between coxa plana and the normal hip; (3) to call attention to the similarity of the reported operative findings in Perthes' disease to those found in normal bone repair; (4) to point out a mechanism whereby the stability in these hips is increased; (5) to discuss briefly the etiology of the condition. This report is based on a study of cases, a review of the literature, and on dissection of the hip joint, verifying the observations of Allis[1] and Walmsley[53], quoted hereinafter.

An analysis of the records of all hip cases entering the out-patient department of the Philadelphia Orthopaedic Hospital and Infirmary for Nervous Diseases for the period between January 1, 1908, and April 1, 1929, was made. Tuberculosis, congenital dislocation, pathological dislocation with infantile paralysis, hypertrophic arthritis with flat femoral head, infectious arthritis, osteomyelitis, sliding femoral epiphysis and facture of the femoral neck were ruled out. There remained the following two groups: (1) thirty-six cases of Perthes' disease, and (2) six cases which showed moderate flattening of the socket with or without slight flattening and lateral displacement of the epiphysis of the femoral head, but always with coxa valga deformity of varying degree. Incomplete records of both types were discarded. The thirty-six cases of Perthes' disease included twenty-six boys and ten girls. Age at onset varied from three to twelve years. A history of mild trauma was present in thirteen. Pain was referred to the knee in seven cases and there were night cries in two cases. All cases showed flattening of the socket, occasionally on both sides.

A CASE REPORT

The following case, showing changes in the femoral head while the socket remained constant, was thought to be of sufficient interest to warrant

*Read before The Philadelphia Orthopaedic Club on November 14, 1929.

FIG. 1

B.K. September 16, 1923. At this examination there is apparently a firm bony ankylosis of the right hip. The outline of the femoral head is merged into the acetabular cavity. No evidence of an active process at present and the process has apparently undergone complete repair. (*Report unsigned.*)

a detailed report. The films are shown through the courtesy of Dr. G. E. Pfahler of Philadelphia.

B.K., a thirteen-year-old white girl, entered Dr. Gill's service in the out-patient department of Orthopaedic Hospital on January 13, 1923, complaining of pain in the right hip. The family history was negative. She was a twin. The previous medical history revealed that following a slight injury to the right hip at the age of ten, she had been treated in three different hospitals with a diagnosis of tuberculosis of the right hip. Her last examination (October 11, 1930) showed one-quarter inch shortening of the right leg; flexion limited to ninety degrees; internal rotation absent; external rotation about one-half normal; adduction, extension, and hyperextension normal. At present (1931), she works as a cashier, standing most of the day, and complains of very slight pain and fatigue in the affected hip on severe or prolonged exertion. Throughout her clinical course, she had three periods of pain lasting from one to two weeks, the last one being four years ago. The first three films in this case cannot be found but the reports dated February 9, 1920, June 16, 1920, and January 6, 1921, all gave the diagnosis of tuberculosis. A film made on February 14, 1922, shows the disorganization of the head with a flattened and widened acetabulum. Unfortunately, this film is not clear enough for reproduction but when held properly to the light, it can be studied quite well. Subsequent films show the outline of the socket unchanged in gross outline, while the head has assumed the coxa plana outline. Figures 1, 2, 3, and 4 with accompanying legends complete this case report.

SUBNORMAL HIPS

Between the normal socket and the extremely flat socket of the congenital dislocated hip, not only does coxa plana appear but also many variations. In a large series of films, often reported as normal, one will not infrequently see rather flat sockets with the femoral head and neck in a coxa valga position, sometimes with a depression in the roof of the acetabulum

FIG. 2

B.K. March 20, 1926. X-ray examination shows apparently complete healing of the right hip. On comparing this with a film made September 16, 1923, one sees the most striking change. In 1923 one could not trace the outline of either the acetabular cavity or outline of head of femur. The shadows of both blended together with an indefinite decalcification or atrophy. The neck of the femur was shortened at that time and also is at present. This shortening of the neck of the femur would still raise the question of the possibility of Perthes' disease or coxa plana. (*Dr. G. E. Pfahler.*)

FIG. 3

B.K. X-ray examination made June 2, 1927, as compared with the films made March 20, 1926, shows practically no changes. This is evidently the affinitive stage of coxa plana or Perthes' disease. (*Dr. Pfahler.*)

FIG. 4

B.K. October 13, 1930. This film shows practically no change from the last previous film. Note the widening of the opposite socket. (*Author.*)

and often with a slight lateral displacement of the femoral epiphysis. The six cases of this type which were isolated have all been observed for at least three years without the development of coxa plana, although each case entered the out-patient department with the complaint of pain in the hip. The following case report illustrates this type of hip, which for want of a better name, is designated as a subnormal hip.

J.Y., a four-year-old white boy, entered the out-patient department of Orthopaedic Hospital on Dr. Gill's service (November 4, 1922) complaining of pain in the right hip with a slight limp. Roentgenograms at this time were reported negative and the film cannot be found. On July 9, 1929, at the age of eleven, he returned to the out-patient department complaining of moderate pain in the right hip. Clinical examination was negative. The roentgenogram (No. 18033) which is given in Figure 5 shows a coxa valga with widening and flattening of the socket on the right and to a lesser degree on the left.

Subnormal hips represent an intermediate type of deformity between the normal hip on the one hand and the mushroom type of coxa plana on the other. A series of films, containing a film each of a normal hip, a subnormal hip, a mushroom type of coxa plana, a capped type of coxa plana and a congenital dislocated hip arranged in the order named, affords an interesting study in acetabular variations. The development and increased use of the Bucky diaphragm and the stereoscopic principle in x-ray work have elevated diagnostic standards and should produce a growing interest in the variations in the outline of the acetabulum.

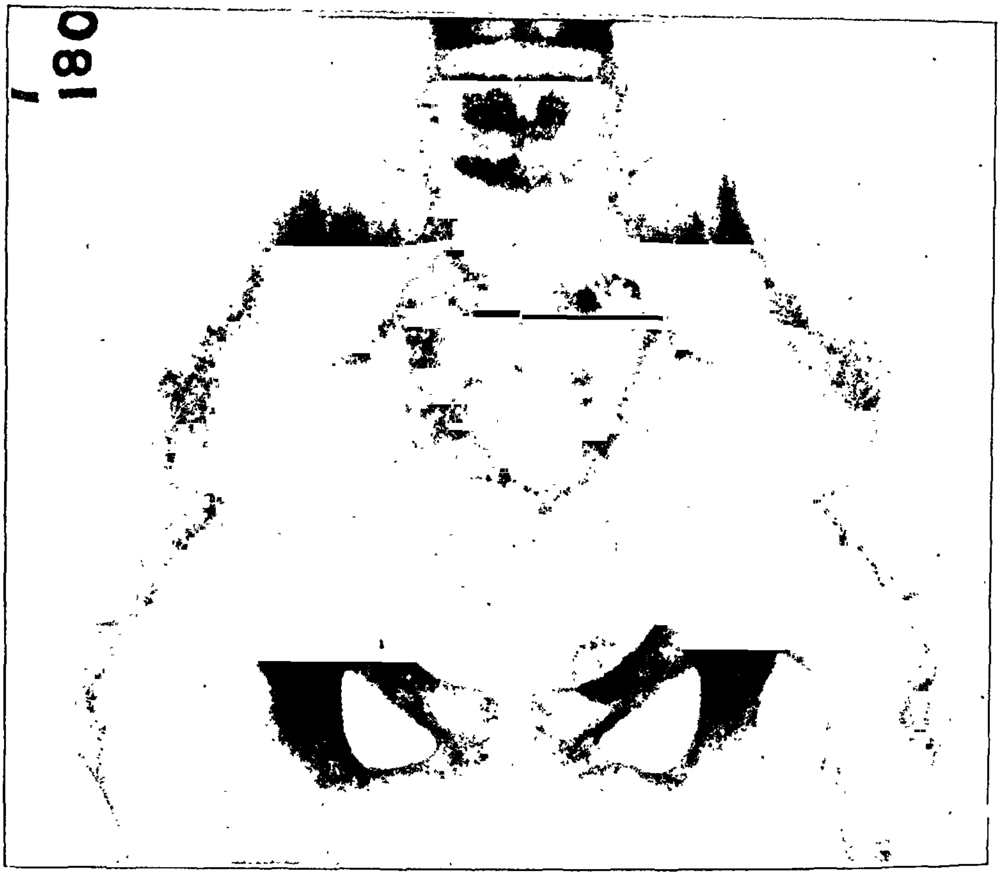

FIG. 5

J.Y. Widened socket with coxa valga on the right, and, to a lesser degree, on the left. (*Author.*)

A COMPARISON OF OPERATIVE FINDINGS IN PERTHES' DISEASE WITH THOSE IN NORMAL BONE REPAIR

The rather transient nature of symptoms in Perthes' disease has rendered histopathological studies rare in this condition. For a clear, detailed study of this kind, we are indebted to Dr. Lippmann[35] who reported on the operative findings in Perthes' disease in a patient from Dr. Whitman's Service. Although Dr. Lippmann has very kindly gone over these slides with me in person, I am not in harmony with his view that these findings probably represent the result of an aseptic infarction in the femoral head area. On the contrary, I was greatly impressed with the similarity of his findings to some of the reported findings in normal bone repair in men and animals.

In his report, Lippmann pointed out new bone formation progressing from two points: (1) from the vicinity of the attachment of the ligamentum teres, and (2) upward through a break in the epiphyseal line. Describing the gross specimen, he stated: "The bone lying between the surface cartilage and the epiphyseal line was yellow in color, in contrast to the normal bone under the epiphyseal line, which was red". The microscopic findings were as follows: "Microscopically, the surface and epiphyseal

cartilages were normal in every way. However, the greatest part of the spongiosa of the epiphysis consisted of a necrotic mass. The bone lacunae in this area were all empty and the marrow was converted into a homogeneous mass in which all cell structure had disappeared. No red blood cells or remains of a vascular system could be identified." This necrotic mass was "bordered by a thin wall composed of vascular mesenchymatous tissue in which polymorphonuclear leucocytes, small lymphocytes, plasma cells, and giant cells are plentifully scattered. In this area, the bone lamellae were thickly covered with osteoblasts and there was evidence of rapid new bone formation."

The above microscopic findings are closely simulated in work on normal bone repair. The yellow-appearing tissue described by Lippmann may be classed as osteoid tissue of which Wieder[56] wrote: "Osteoid tissue, when seen in ground section, is not as dense in structure and has a deeper yellow tinge than normal cortex, probably due to some difference in chemical composition". Wieder also stated: "In the medullary cavity there are the remains of osteoid trabeculae, which show considerable absorption". Bast, Sullivan and Geist[3] wrote: "In the removal of the internal callus the osteoclasts play a part; in cases, however, where the internal callus is large, a process of bone destruction takes place, which process we have defined and described as 'bone dissolution' in our description of the fifteenth-day stage. This dissolution, which has the appearances of both fatty and mucoid degenerations, is noted as early as the ninth day". Wieder also noted myxomatous tissue in the spaces of the periosteal trabeculae and in the cortex.

C. C. Macklin[38] found many different cell types present, in his work on bone repair, and stated: "Polymorphonuclear leucocytes are often seen in the tissues of the fracture area". He gave his views in brief when he stated: "To anyone familiar with the literature it will be quite obvious that the behavior of these phagocytes, in the reaction following bone injuries, is quite like that which obtains in the repair of any damaged tissue, and thus the problems involved are those common to inflammation". Bast, Sullivan and Geist also reported numerous phagocytes present in normal bone repair.

If we accept the more recent work done in bone repair, the theory of vascular occlusion is unnecessary in the explanation of the changes occurring in Perthes' disease as recorded by Lippmann. Leriche and Policard[35] emphasize the point that bone rarefaction and absorption always accompany new bone formation, and state that bone rarefaction is never found without hyperaemia. The work of Todd and Iler[52], as well as the work of the writers mentioned above, shows the simultaneous vascularization and erosion of bone in bone repair and Todd and Iler quote John Hunter to show that there is nothing new in this observation. Moreover, Pemberton and his associates[21] among others, produced new bone by tying off the circulation to the patella in dogs. From a survey of recent work in bone repair and bone change, it is evident that vascular occlusion, often of pathological significance elsewhere in the body, seems to be a normal finding where bone change is taking place.

Another observation made by Lippmann which would seem to be important, is the following: "The acetabulum was normal except that at the point where the ligamentum teres was attached there was a marked congestion and thickening of the soft tissues". This would indicate that the hyperaemia was not confined to the ligamentum teres, but began outside of the joint and at some point proximal to the branching of the articular branch of the obturator vessel which supplies the acetabulum as well as the ligamentum teres.

STABILITY IN COXA PLANA

If one accepts the view that these acetabula are flattened and widened from birth, then the question arises as to why these hips do not commonly dislocate under the stress and strain of active childhood. As long ago as 1896, Allis[1] pointed out the prominent part played by internal rotation in the production of dislocations of the hip and he emphasized the capacity of the iliofemoral ligament to act as a fulcrum in the position of extreme flexion, adduction, and internal rotation. The long lever arm is the bent leg; the short arm is the head and neck at an angle of approximately 127 degrees to the shaft of the femur. In the development of coxa plana, the shortening of the neck and the straightening of the head and neck into a

FIG. 6

J.G. Twenty years after onset. Coxa plana on the left; widening of the socket on the right.

coxa valga destroy the short arm of the lever (See Figure 6) which with internal rotation is so productive of dislocation in the normal hip. There is a resultant increase in stability, for the joint is adjusted to withstand the extremes of internal rotation, flexion, and adduction. Allis wrote: "At first glance one can see nothing in rotation to disturb the position of the head; for were the femur a straight bone and the capsule of equal strength and length, the whole might be twisted off, leaving the head still in the socket". The same principle*, in a lesser degree, may be applied to those cases in which only coxa valga results from contact with the flattened and widened socket. The loss of range of motion in coxa plana is a well established clinical observation, with the amount of limitation being proportional to the degree of deformity present.

DISCUSSION OF ETIOLOGY

That one of the first theories of etiology was the infectious, and that organisms were eagerly sought in curettings and more rarely found, is not surprising in view of the fact that bacteriology was the last of the fundamental medical sciences to be developed. After almost twenty years of effort by careful workers no organism has been demonstrated consistently in this condition. These patients show no more signs of a cryptogenic infection than do cases of congenital dislocation of the hip.

The theory of vascular occlusion with infarction does not carry the weight which it did before the more recent studies in bone repair were made. Rarefaction and hyperaemia have been shown to be correlated processes in normal bone change. The pain present in these cases is similar to and not more severe than the pain present wherever bone repair is taking place. Occurrence of bilateral coxa plana and of congenital dislocation on one side with coxa plana on the other, does not fit in well with either of the above theories. Likewise, the rather strictly limited age incidence for Perthes' disease is not easily explained by infection or vascular occlusion. Legg[32], in differentiating the mushroom and capped types, placed before the profession the problem of finding a variable causal factor. Such a factor is seen in the varying degree of flattening and widening of the acetabulum, but it is not readily discernible in infection or vascular occlusion.

The belief that the head flattens the acetabulum, expressed by some, disregards the screw-like action of the hip joint as shown by Walmsley[33]. He demonstrated that the arrangement of the fibers in the capsule of the joint tends to force the head with a screw-like motion into the socket in

*For the writer, this bit of applied anatomy has also served to explain: (1) the surprising stability of certain cases of hypertrophic arthritis with flattened femoral head, greatly weakened by absorption of lime salts and with cyst formation; and (2) the noteworthy stability following the operation for congenital dislocation of the hip in which the roof of the acetabulum is turned down; for in most of these cases the femoral head and neck have been straightened into the long axis of the femur, making it a straight bone, by constant pounding against the side of the ilium; or the head has been practically sessile on the upper end of the femur since birth.

extension which is the normal weight-bearing position. If Walmsley's observations are correct, one would expect a deepening effect on the socket by the femoral head, even though flattened.

Assuming that the bone changes in the femoral head are examples of normal bone repair in an area of injury caused by a flattened socket, the question of what institutes the process still remains unanswered. The irritation produced by the incongruity of the parts in the joint might produce a local hyperaemia which would yield a rarefaction of the femoral head of sufficient degree to permit a crushing fracture by the body weight. External trauma might initiate the same course of events in a shorter period of time.

It is a pleasure to express my appreciation to Dr. W. J. Taylor, Dr. A. P. C. Ashhurst and Dr. A. B. Gill for permission to study these cases which were taken from their services at Orthopaedic Hospital; to Dr. R. S. Bromer, roentgenologist to Episcopal and Orthopaedic Hospitals, for his many kindly suggestions; and to the Social Service Department of Orthopaedic Hospital for its aid in following these patients.

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THE RANGE OF ACTIVE ABDUCTION AND LATERAL ROTATION AT THE HIP JOINT OF MEN

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From the Department of Anatomy of Stanford University

One hundred men, in good health and free from any physical handicaps, were selected for measurements to determine the amplitude of abduction and lateral rotation at the hip joint. Seventy-five per cent. of the students were in the first and second year of medicine; the remaining twenty-five per cent. were other university students. The men ranged in age from seventeen to thirty years. Of the one hundred individuals, eighty-two were in the third decade of life and eighteen in the second decade.

At the suggestion of Dr. Meyer, the apparatus shown in Figure 1 was constructed for making these determinations. It consisted of two heavy wooden uprights, six feet, eight inches high, separated by a distance of two feet, ten inches. These uprights bore vertical slots upon which an adjustable sliding back rest was placed, the whole being adequately braced and mounted upon a solid wooden base. On the top of the uprights was placed a wooden hood bearing lateral grips on the under surface near the front, by means of which the individual being measured steadied himself. In order to secure fixation of the pelvis against the back rest a broad canvas strap was passed in front of the individual to be measured in the region of the anterior superior spine of the ilium, thereby firmly fitting the lumbar curvature to the pad on the back rest. The latter bore a protractor with an adjustable arm which could be extended to the lateral malleolus, when measuring abduction. The center of the protractor could be adjusted to the anterior posterior and transverse point of rotation. The readings were made from these circular protractors which were centered at the axis of rotation.

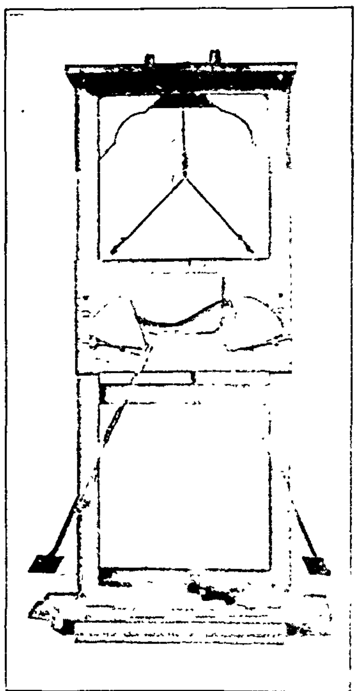

FIG. 1

A photograph of the apparatus taken from the front.

For measuring the lateral rotation of the lower extremity, one foot was placed on an adjustable carrier which had as its center of rotation a vertical line which passed

through the middle of the calcaneum. The other foot was placed on a firm block of equal height. The tip of the carrier bore an indicator having for its center the center of the calcaneum. This indicator was moved with the carrier by the foot over a large protractor which was centered beneath the calcaneum, and the amount of rotation was measured in degrees on these protractors. In order to assure a smooth surface for the rollers beneath the carrier, a piece of sheet metal was interposed between the rollers below the carrier and the base. The carrier moved easily, but errors due to momentum were guarded against.

In measuring abduction of the lower extremity, the hands of the operator were placed over each trochanter to detect and guard against any movement of the pelvis. Abduction was carried out rather slowly to prevent error due to momentum and yet with a sufficient degree of speed to assure a full movement.

Two or three preliminary trials in each movement were made to accustom and to instruct the individual. Four to seven successive readings were taken by the observer for each motion, and recorded. These measurements

WORK SHEET

NUMBER 2 Date *Oct. 29, 1929*

Name in full.. Height *5'11"*

Weight *170*

Address..Age *22*

Remarks: Played football *2 years, 1925–1927.* Trained on track *Consistently for 3 years before 1924.*

Rides bicycle. *Before 1924.* Dances. *Infrequently.*

Swam frequently during past year, particularly the breast stroke requiring "frog" kick.

MEASUREMENTS

	Right Trials	1	2	3	4	Average
Rotation	Lateral	*60.8°*	*59.5°*	*61.°*	*61.°*	*60.6°*
	Abduction	*42.°*	*41.5°*	*41.5°*	*42.5°*	*41.8°*

	Left Trials	1	2	3	4	Average
Rotation	Lateral	*61.°*	*63.°*	*62.5°*	*63.°*	*62.3°*
	Abduction	*42.°*	*41.°*	*40.5°*	...	*41.6°*

did not differ more than five degrees. The average of these readings was recorded as the range of motion for that individual.

Most of the persons measured were medical students at Stanford University, who appreciated the object of the measurements and who co-operated to the fullest extent in order to eliminate errors. It is a pleasure to acknowledge indebtedness to them and also to Dr. Meyer for his help. A copy of the work sheet is given herewith. Special inquiry was made regarding the existence of disease or its past history and anything that might affect the freedom of motion in the hip joint.

The individual data on weight, height, age and amplitude of motion are found in Table I.

The average and the maximum amplitudes were as follows:

Average Amplitudes

	Abduction	*Rotation*
Right	36.3°	50.8°
Left	35.3°	51.3°

Maximum Amplitudes

	Abduction	*Rotation*
Right	59.6°	68.5°
Left	51.1°	69.3°

Minimum Amplitudes

	Abduction	*Rotation*
Right	24.0°	25.6°
Left	23.6°	30.5°

The distribution of cases on either side of the average was approximately the same, in abduction and in rotation. Although the average range in abduction was somewhat greater on the left and that of rotation on the right, the amount of the former was less than two degrees and that of the latter was a little less than five degrees. Hence it is unlikely that any special importance can be attached to these differences.

The relation of age to the range of motion could not be determined because the group was mostly from the third decade. This was too short a period to reveal any difference. It was not possible to arrive at any conclusions regarding the relation of weight to the range of motion due to the fact that the differences in weight were slight and the group small. The average weight was about 150 pounds.

A comparison between Gilliland's results and the author's is as follows:

Gilliland	*Abduction*	Boscoe	*Abduction*
Right	54.5°	Right	36.33°
Left	54.5°	Left	35.34°
Range	35°—80°	Right	24.0°—59°-6°
		Left	23.5°—51-1°

The high averages given by Gilliland, as well as his maximum abduction of almost eighty degrees, seem to indicate that they are due to errors of

TABLE I

Individual Measurements and Other Data Obtained From 100 Men

	Weight	Height		Age	Lateral Rotation, Right	Lateral Rotation, Left	Abduction, Right	Abduction, Left
	Pounds	*Feet*	*Inches*		*Degrees*	*Degrees*	*Degrees*	*Degrees*
Case 1	180	6	2	20	50.2	53.9	33.3	30.6
Case 2	170	5	11	22	60.6	62.3	41.8	41.2
Case 3	143	5	8	21	60.2	62.1	34.0	30.1
Case 4	143	5	9	20	67.8	54.4	33.8	31.4
Case 5	143	5	10	20	55.9	52.6	29.9	35.1
Case 6	145	5	11	20	53.7	69.3	37.9	37.7
Case 7	152	5	11	29	57.6	48.1	44.5	44.1
Case 8	140	5	9	23	65.6	63.4	44.2	44.0
Case 9	155	5	11	21	32.0	30.5	38.9	39.7
Case 10	153	6	..	22	58.6	60.8	34.7	37.8
Case 11	145	5	10	21	49.6	45.8	36.2	34.6
Case 12	152	5	10	20	60.6	58.1	32.5	33.6
Case 13	168	6	1	24	44.1	41.4	29.9	29.8
Case 14	170	5	11	22	49.7	54.9	29.4	23.6
Case 15	165	5	10	19	60.6	63.1	33.2	28.2
Case 16	165	5	9½	20	30.1	59.8	27.2	29.3
Case 17	164	5	8	21	32.4	39.3	27.5	29.0
Case 18	110	5	2	25	56.5	64.5	39.8	42.4
Case 19	174	5	9	21	66.2	64.4	44.0	44.5
Case 20	130	5	10	20	39.8	43.0	35.2	32.8
Case 21	149	5	8	27	43.3	42.1	38.3	37.7
Case 22	135	5	7	24	57.5	57.0	32.6	31.6
Case 23	144	5	10½	26	43.5	40.9	31.6	30.3
Case 24	135	5	4	22	61.6	66.4	42.6	44.7
Case 25	130	5	9¼	21	53.1	53.4	30.0	26.8
Case 26	140	5	8	25	56.6	61.3	40.9	44.5
Case 27	160	5	9	22	49.5	47.9	31.9	31.4
Case 28	150	5	8	21	62.4	63.3	30.3	28.9
Case 29	195	5	9	21	46.4	44.8	36.3	38.0
Case 30	123	5	5	21	66.2	66.7	52.1	51.1
Case 31	145	5	8	30	53.1	55.0	34.8	32.7
Case 32	187	5	11	23	49.2	50.3	32.3	32.5
Case 33	140	5	6¾	22	41.2	46.3	34.3	32.8
Case 34	160	5	11	21	44.6	44.2	35.4	37.3
Case 35	167	5	10½	17	50.8	35.4	31.8	31.3
Case 36	137	5	9½	22	50.6	34.5	27.8	27.5
Case 37	200	6	..	22	61.1	61.1	35.6	35.5
Case 38	150	5	6	21	44.0	45.1	37.6	34.5
Case 39	125	5	5	25	46.3	54.0	33.1	33.9
Case 40	134	5	9	22	55.8	60.2	35.7	33.5
Case 41	150	5	11	23	44.1	49.1	37.0	34.0
Case 42	140	5	7½	20	39.1	47.4	29.4	31.7
Case 43	160	6	¾	20	57.2	58.3	36.2	33.0
Case 44	155	5	10¾	22	34.7	36.7	24.0	24.8
Case 45	210	6	..	25	51.5	40.7	39.1	34.4
Case 46	165	5	10½	18	53.5	60.0	44.3	41.9
Case 47	155	6	1	22	54.8	54.9	33.2	32.1
Case 48	148	5	11½	25	46.4	46.3	31.8	31.6
Case 49	135	5	10	22	45.0	49.5	33.9	35.8
Case 50	162	6	..	22	54.9	54.7	42.5	39.3

TABLE I—*Continued*

INDIVIDUAL MEASUREMENTS AND OTHER DATA OBTAINED FROM 100 MEN

	Weight	Height		Age	Lateral Rotation, Right	Lateral Rotation, Left	Abduction, Right	Abduction, Left
	Pounds	*Feet*	*Inches*		*Degrees*	*Degrees*	*Degrees*	*Degrees*
Case 51	185	6	2½	25	59.0	60.4	35.8	35.0
Case 52	136	5	5	22	42.3	45.7	28.5	28.1
Case 53	191	6	3	22	50.2	48.5	38.1	34.7
Case 54	125	5	8	26	54.1	65.9	39.0	39.3
Case 55	175	5	9	23	59.1	57.6	37.1	31.0
Case 56	160	6	2½	22	46.3	42.8	36.6	34.3
Case 57	146	5	9	21	45.5	41.8	33.3	32.8
Case 58	165	6	..	26	57.6	63.6	40.9	38.0
Case 59	160	5	11½	21	52.2	38.4	38.8	28.4
Case 60	134	5	6	22	56.4	60.4	33.6	34.1
Case 61	150	6	¾	21	46.6	47.8	32.4	33.3
Case 62	142	5	8	23	25.6	30.8	32.9	30.1
Case 63	140	5	6	20	56.8	64.6	34.9	34.6
Case 64	180	5	10½	21	47.6	44.3	31.6	29.3
Case 65	132	5	6¼	27	44.3	37.9	36.5	36.6
Case 66	135	5	9	21	46.3	46.8	35.4	33.0
Case 67	155	5	10½	21	47.9	49.7	28.3	28.6
Case 68	130	5	5	24	45.1	44.3	44.1	40.8
Case 69	173	5	9	23	62.6	50.4	29.9	38.0
Case 70	172	5	9½	21	45.4	39.8	34.9	37.3
Case 71	190	6	1	21	55.2	54.4	37.2	34.8
Case 72	153	5	9¼	21	49.2	51.8	32.3	28.7
Case 73	156	5	11	21	40.4	37.9	27.4	29.1
Case 74	150	5	11	21	50.4	55.9	32.6	31.5
Case 75	143	5	8½	21	49.2	46.3	35.5	36.7
Case 76	178	6	1	21	50.5	57.3	44.5	44.6
Case 77	179	6	..	20	51.8	50.1	31.3	30.1
Case 78	160	5	8	22	68.5	67.4	35.6	36.2
Case 79	198	6	5¼	20	39.7	39.6	34.0	34.2
Case 80	157	5	10½	22	49.6	51.9	38.4	38.8
Case 81	161	6	1	24	46.2	47.2	40.0	38.1
Case 82	157	5	7½	26	45.5	47.7	30.9	29.6
Case 83	161	5	10½	20	42.9	43.7	59.6	50.7
Case 84	152	5	7	25	65.9	63.4	57.9	48.5
Case 85	190	5	10	21	63.1	59.4	38.2	41.2
Case 86	141	5	8	18	46.5	45.8	40.0	36.6
Case 87	165	5	11	21	63.3	57.1	43.6	40.8
Case 88	150	5	10½	21	41.0	53.6	38.3	35.3
Case 89	140	5	7½	21	53.3	42.2	41.7	39.2
Case 90	143	5	6¾	24	48.9	45.6	44.8	39.7
Case 91	184	5	9	23	54.2	56.3	43.2	43.1
Case 92	135	5	8	24	40.3	41.7	36.5	35.6
Case 93	135	5	8	23	47.8	56.7	39.6	40.0
Case 94	150	5	7	22	42.1	57.3	37.9	34.8
Case 95	160	5	11	20	49.0	55.9	44.2	37.3
Case 96	160	5	7	21	61.4	56.6	38.2	38.6
Case 97	130	5	10	21	49.7	46.3	37.8	34.2
Case 98	125	5	8½	23	57.8	49.6	37.7	38.9
Case 99	150	5	6	22	47.0	45.9	33.1	38.9
Case 100	149	6		24	50.7	50.4	35.3	36.9
Average 100	151			21.1	50.81	51.34	36.33	35.34

observation. The most likely thing is that lateral flexion of the trunk was not prevented. Anyone can easily convince himself of this by personal trials when standing freely and when supported against an object which prevents lateral flexion of the trunk. Anyone who is allowed to stand unsupported will flex the trunk to the opposite side as soon as abduction of a lower extremity becomes at all marked and an abduction of eighty degrees is not possible in any normal case because the neck of the femur impinges on the margin of the acetabulum long before that amplitude is reached, even in a skeleton. It follows that therapy (Albee and Gilliland), based on averages which are not reliable, must prove disappointing unless only improvement and not the attainment of a mistaken standard is sought.

According to Strasser, the amount of abduction of the lower extremity in anatomical preparations is fifty-four degrees. Strasser says that lateral rotation as determined by Strasser and Gassmann is at least fifty degrees in the semiflexed position of the thigh. Strasser further states that Fick (A.) found it to be forty-nine degrees, Weber fifty degrees, Krause forty to sixty degrees, and Braune, Henke, and Fick (R.) ninety degrees. Strasser wisely emphasizes, however, that all these measurements were obtained on ligamentous, anatomical preparations and that, in general, all movements are larger on such preparations than on the living individual. This statement of Strasser's is abundantly confirmed by the writer's measurements on the living.

The amplitude of motion observed in the living individual probably is somewhat dependent upon the reactivity of the individual, the extent of his muscular control, and ordinarily, to a minor extent, upon the anatomical conditions at the hip joint. Since maximal motion in abduction probably is checked by contact of the neck of the femur with the acetabular margin, it follows that the angle of the femoral neck, as well as the configuration of the latter and the slope of the coxal bone, probably are factors which influence the range of motion in abduction.

An inspection of the tables, fields, or graphs indicating the amplitude of abduction shows that it seldom is exactly the same on the two sides. However, it differs only by one degree or less in twenty-seven per cent. of the cases. It differs two degrees or less in fifty-five per cent. and five degrees or less in ninety per cent. of a 100 cases. Since the error in measurement probably lies somewhere in the neighborhood of three to five per cent., this correspondence in the amplitude of motion on the two sides really is quite significant and implies that the method used probably is reliable and that the group of individuals measured was decidedly homogeneous.

A similarly striking correspondence was observed in the range of lateral rotation. In seventeen per cent. of the cases it differed only one degree or less on the two sides. In thirty-nine per cent. it differed two degrees or less and in sixty-eight per cent., five degrees or less. The somewhat lesser correspondence between the two extremities in lateral rotation than in abduction may be due to the fact that these movements are exercised

relatively seldom, except indirectly, as a rule by rotation of the trunk upon the leg supporting the body weight.

SUMMARY

1. The greatest range of rotation of the right leg was forty-two and nine-tenths degrees; for the left, thirty-eight and seven-tenths degrees. The average range of rotation for the right was fifty and eight-tenths degrees; for the left, fifty-one and three-tenths degrees.

2. For right abduction the range was thirty-five and six-tenths degrees; for left, twenty-eight and five-tenths degrees. The average was thirty-six and three-tenths degrees and thirty-five and three-tenths degrees respectively.

3. No relation between the range of motion, either in abduction or rotation, and weight and height was established. The group measured was of relatively uniform weight and age.

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A PLASTIC OPERATION FOR RELIEF OF RECURRENT SLIPPINGS AND DISLOCATION OF THE PATELLA

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Slipping patella is the term, according to Whitman, applied to ab normal laxity of the supporting tissues that allows the occasional displace ment of the patella upon, or to the outer side of, the external condyle of th femur. The predisposing causes of this condition may be grouped unde three main headings in the order of the frequency of their occurrence (ex cluding traumatism and congenital defects): first, knock-knee; second abnormal laxity of the capsule of the knee joint and the patellar tendon; anc lastly, the imperfect development (flattening) of the external condyle o the femur.

REASONS FOR MODIFICATION

There have been a great many types of operations devised—such as those of Goldthwait, Krogius, Soutter, Gallie, and Albee—and successful results with these procedures have been reported, but recurrences are noted. It seems that each operation described is for only a certain phase in the slipping or dislocation, and not based on the direct cause of the condition,—namely, the *abnormal lateral attachment of the patellar tendon with its secondarily relaxed capsular ligaments to the inner side of the knee.*

TYPE OF CASE

In the cases of slipping patella associated with marked genu valgum it is sufficient to correct the deformity by osteotomy of the femur. The flattened or deformed lateral condyle of the femur being the predisposing factor, the technique of Albee by means of a bone-graft wedge is sufficient to overcome the disability and restore normal function. There still remains the greatest number of cases of dislocation of the patella, including "mild snapping and transient catchings" with signs and symptoms referred to the region of the internal semilunar cartilage, which are claimed by Bennett to be due to relaxed internal ligaments, but are more often caused by *malalignment of the patellar tendon,* for which this plastic operation is devised. It is based on the principles of all the operators as described in the bibliography.

TECHNIQUE

The principle of the operation is to correct the lateral displacement of

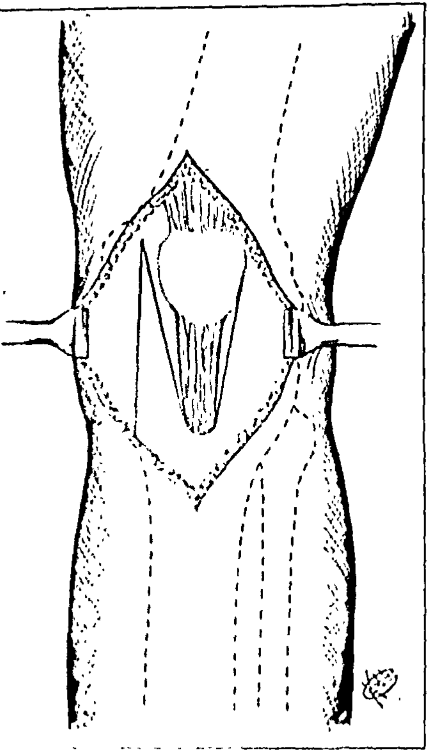

FIG. 1

Shows lines of incision in medial capsule knee joint and around patellar tendon.

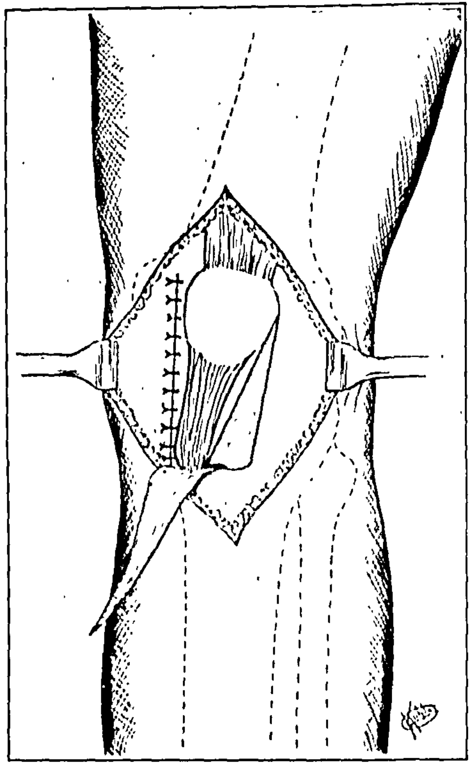

FIG. 2

Shows segment of capsule reflected downward and patellar tendon transplanted to medial surface of upper part of tibia.

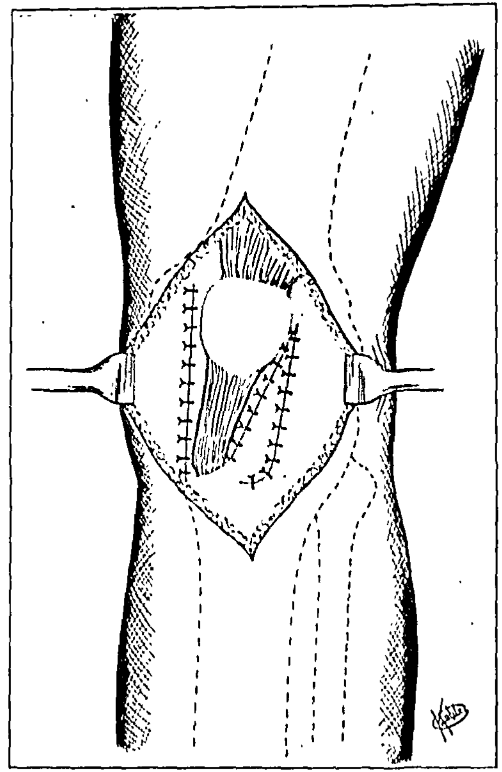

FIG. 3

Shows patellar tendon in new position and internal capsular segment transplanted to defect on lateral surface of knee. The patella is also in new position making the pull of extensor

attachment, to the medial position in order that the extensor apparatus of the leg may pull in a straight line; and, at the same time to correct the relaxation of the medial capsular ligaments by this displacement of the patella medially. A curved incision, about six inches in length, is made medial to the patellar tendon, reflecting the skin and subcutaneous tissues. The entire patellar tendon, including its periosteal attachment, is freed by two lateral incisions as shown in Figure 1. A large flap of medial capsular ligaments in the shape of an inverted letter V is reflected and kept attached at its base. The synovial membrane is left intact and the joint is not entered. The patellar tendon is given a new attachment medially (Fig. 2), and the patella is displaced inward, being sutured in the new attitude to the incised capsular ligaments from which the flap was removed. The reflected wedge-shaped section of the medial capsular ligaments is now transplanted into the defect already formed in the lateral surface of the patella as shown in Figure 3. The skin is closed in the usual manner and a plaster-of-Paris dressing is applied. Walking is encouraged after about three weeks following the operation and all support is removed at the end of six weeks, when active movement is begun. Complete recovery may be expected in approximately three months following the operation.

RESULTS

The success of the above procedure has been most gratifying and no recurrences have been noted. It is surprising to note a marked improvement of the knock-knee deformity, which was associated in a mild degree with the cases of habitual dislocation in children, and the entire relief from pain in those suffering from relaxation of the ligaments about the internal aspect of the knee joint.

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THE OPERATIVE TREATMENT OF CLAW-FOOT*

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The object of this paper is to present an operative method for the relief of claw-foot used in fifteen cases. Although this number of operations is not large, the uniformly good results in this series of cases justifies the recommendation of the procedure as a most satisfactory method to relieve claw-foot. At the time these operations were done the writer was not familiar with the work of Sherman[1] or Forbes[2] published a number of years ago, and can therefore claim no originality for the method, except for a very important detail not mentioned by either of these writers, and to his knowledge not mentioned elsewhere,—namely, a capsulotomy of the metatarsophalangeal joints. It has been found that a capsulotomy of the metacarpophalangeal joints is sometimes necessary to obtain flexion of stiff fingers, as was described by the writer in 1924[3]. Similarly, a capsulotomy of the metatarsophalangeal joints has been found most useful in the treatment of claw-foot. Any tendon transplantation or operation directed to soft parts alone cannot be expected, of course, to correct those most severe claw-foot or cavus deformities described by Jones[4] as belonging to Class V, because in these cases the secondary bony deformity is so great as to preclude correction without radical wedge resection with shortening of the foot. On the other hand, the operation proposed here is believed to be sufficient for the relief of symptoms in all excepting the most severe types, even though a complete restoration to normal form of the tarsus is not obtained in the most severe cases.

Relief of symptoms—*i.e.* painful calluses under the metatarsal heads, hammer-toe deformity with painful corns, the impossibility of wearing any type of shoe with comfort, and the symptoms of foot strain—can be accomplished without the necessity of the radical operation of wedge resection. It has been frequently observed that after the deformity has been relieved by extensive wedge resection of bone, the foot is left so shortened and out of proportion that the difficulty of shoe fitting remains as pertinent as before. The deformity is characterized by an exaggeration of the arch with a contracture of the plantar fascia, a contracture of the long extensor and flexor tendons with dorsal subluxation of the toes at the metatarsophalangeal joints, accompanied by a depression of the metatarsal heads. When the patient stands, no part of the toes comes in contact with the floor. There are usually painful corns, and callosities under the metatarsal heads cause great discomfort. Of particular importance is the contracture of the ligaments and capsules on the dorsal aspect of the metatarsophalangeal joints.

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This point has not been previously emphasized, and the writer believes that a capsulotomy of these joints is an essential part of any operation for the correction of claw-foot.

USUAL METHODS OF TREATMENT

In those cases severe enough to require treatment various conservative methods have been proposed. Simple tenotomy with *forcible wrenching* of the foot is sufficient in only very mild cases. Steindler's operation[5], stripping of the os calcis, does not relieve the deformity at the metatarsal heads and toes. Transplantation of the extensor longus hallucis into the metatarsal head, or into the flexor tendon, according to Dickson and Diveley[6], cannot relieve the deformity of the other toes. The tendon transplantations of Sherman, Forbes, and Hibbs[7] will not correct a fixed hyperextension deformity of the metatarsophalangeal joints. The Hoffman[8] operation should correct this deformity, but it would appear to the writer, who has had no experience with the procedure, to be necessary in only most severe cases. The operation proposed by Spitzy[9] continues still further the stripping of the os calcis by Steindler to include a division of the inferior calcaneonavicular and calcaneocuboid ligaments.

METHOD OF TREATMENT IN THIS SERIES OF CASES

Except in those cases with a marked bony deformity, the problem can be met by directing attention to relieving the contracture of the soft parts, and transplanting the long extensor tendons into the metatarsal heads. This requires a capsulotomy of the metatarsophalangeal joints in order to correct the dorsal subluxation of the toes. If the plantar fascia and muscles are taut, they are divided subcutaneously, and the foot is manipulated to stretch the plantar structures as much as possible. The tendon of the extensor longus hallucis is then transplanted into the head of the first metatarsal in the usual manner, and an arthrodesis is done of the interphalangeal joint of the big toe. A curved incision is then made on the dorsum of the foot, beginning at the base of the second toe, and extending laterally over the other metatarsophalangeal joints and a short distance along the dorsal surface of the fifth metatarsal bone. This transverse incision is used in preference to longitudinal incisions in order to avoid subsequent contracture of the scar in the long axis of the wound which would prevent the maintaining of complete flexion of the toes. The extensor longus tendons are isolated and are divided over the proximal phalanges. If the brevis tendons are taut, these are also tenotomized. After subperiosteal exposure of the distal ends of the metatarsal bones preparatory to tendon transplantation, it is seen that even now the dorsal subluxation of the toes cannot be corrected, and the metatarsophalangeal joints cannot be flexed beyond the neutral position. The capsule of each metatarsophalangeal joint is now divided transversely, and immediately complete flexion of the proximal

phalanges is possible, thus relieving the subluxation and the prominence of the metatarsal heads at the plantar surface of the foot. While capsulotomy is rarely necessary at the big toe, it is always necessary at the lesser toes. There is no difficulty in passing the tendons through drill holes in the metatarsal heads, providing a little care is used to make these holes sufficiently large, and to use a properly suited, shortly curved needle to carry through the silk. The arthrodesis of the interphalangeal joint of the big toe is done chiefly to prevent difficulty in putting on the shoe, caused by the uncontrolled flexion of the distal phalanx. It has not been found necessary to do an arthrodesis of the interphalangeal joints of the lesser toes unless a true hammer-toe exists. A plaster bandage is applied, extending over the ends of the toes and molded so as to stretch the plantar fascia, lift the metatarsal heads, and forcibly flex the metatarsophalangeal joints.

DISCUSSION

Fifteen operations have been done on eleven patients, four of these being bilateral cases. In every case the fixed deformity at the metatarsophalangeal joints has been overcome, and the prominence of the metatarsal heads on the plantar surface of the foot corrected. In all cases there has been a relief of symptoms. While the functional result is excellent in all cases, no claim is made that a complete restoration to normal form was accomplished in the more severe deformities of the tarsus. In one bilateral case the deformity was so severe that a preliminary triple arthrodesis was done to correct the varus deformity. Following capsulotomy and tendon transplantation at a later date, the result was completely satisfactory to the patient.

Infantile paralysis was unquestionably the cause of the deformity in five cases, and these were all unilateral. None of the bilateral cases was classified as due to infantile paralysis. The deformity in the bilateral cases was equally severe in each foot, and there was no indication of muscle weakness elsewhere. In four unilateral cases also there was no definite etiological factor apparent, although it is possible they may have been the result of an unrecognized infantile paralysis. Excepting in those cases definitely the result of infantile paralysis, there was no evidence of any derangement of the cord or roots, although it is admitted that no roentgenograms of the spine were made. There was no positive Wassermann in any case.

SUMMARY

A method for the correction of claw-foot is described. This consists of a capsulotomy of the metatarsophalangeal joints and transplantation of each individual extensor longus tendon into the corresponding metatarsal head. The results of fifteen operations are reported.

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CALCINOSIS INTERSTITIALIS UNIVERSALIS*

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Calcinosis interstitialis universalis (*Kalkgicht*) or arthritis nodosa (described by Neuwirth) are terms applied to that rare and peculiar disease involving the calcium metabolism, the etiology of which is not clear and the treatment for which has not been determined. This short paper is, therefore, an attempt to add a few facts to our scanty knowledge based upon single cases in the literature.

Clinically this disease shows multiple deposits of calcium salts in the subcutaneous, periarticular, peritendinous, perimuscular, perinervous, perivascular, adipose (Tilp), or interstitial tissues. These deposits vary in size from a millet seed to a pigeon egg, and usually have the appearance of platelets, clots, or crumb-like masses, with smooth but mostly uneven edges. Each case differs as to the distribution of the calcium deposits, as well as to the tissue that they select. In the Versé case, for instance, the extent and contour of the deposits along the sides of the body and the front of the abdomen resembled a breastplate; in another case given by the same author, they formed a compact tube around the trunk of the ischiatic nerve. Aisenberg described calcium deposits surrounding the vessel walls of the thigh and shoulders. In the Riese case, they appeared on the finger tips after a needle prick. However, one finds such deposits mostly grouped about the larger joints around the attachments of the tendons and aponeuroses, resulting in reduced motion or even immobility, and producing malposition of the limbs. Occasionally they present a symmetrical distribution (Schulze, Aisenberg).

The literature has no uniformity of data as to the chemical nature of these deposits called by some authors carbonates, by others phosphates. In the Wolff case is noted: "great similarity of these deposits to the bone substance".

All ages are subject to this disease, but most authors agree that in younger individuals it is more widely distributed and clinically more acute. In the areas of localization of the calcium, ganglionic abscesses may form, which discharge a "gruel-like" mass. Repeated infection often aggravates the condition and the disease has sometimes a fatal termination, as for instance in the Versé case. With adults, on the contrary, the location of the disease is more limited in its distribution and its clinical course more

*Case Report presented at the Surgical Section of the Kiev Scientific Medical Society.

benign. Such forms, some authors (Krause, Trappe) speak of as "calcinosis interstitialis progressiva" and "calcinosis interstitialis regressiva". In a series of reported cases the disease sometimes began without any definite cause and no pathological symptoms were evident. In other cases there were noticed adenomata of the epithelial structures (Selye); hypoplasia of inner genitalia and, in connection with menstruation, marked variation in the calcium content of the blood (Shamoff); nephritis (Schnitzer, Selye); tuberculosis (Lowenbach); scleroderma (Dietschy, Jacobsohn, Krause, and Trappe); rachitic affections of the whole skeleton (Schulze); and joint involvement.

Infectious disease sometimes preceded this condition: in Parkes' case the patient had had scarlet fever and diptheria two years before; in Aisenberg's case there had been malaria. Most authors note an atrophy of the skeleton with this disease (von Gaza, Marchand, Wolff, Aisenberg, Schulze); and Schulze states that this must be considered not as the result, but as the beginning of the disorder in the calcium metabolism.

CASE REPORT

D. R., German peasant, aged forty-three years, was seen on December 24, 1929, in the Traumatologic and Orthopaedic Section of the Institute, complaining of great difficulty in walking, due to contraction of the knee joint.

The patient gave the history that at the end of 1922 he had some kind of infection, with high temperature, and five months later began to "swell". This swelling was "dropsy-like" and began about the pelvis and femur, and spread uniformly over the entire body. The skin was oedematous and pitted. This general oedema lasted for three years and was accompanied by diffuse pains. The patient was unable to move the limbs; urination was frequent. At the end of this period the oedema diminished, and the patient began to walk on crutches; but the pains in the limbs continued. After the disappearance of the oedema, large compact subcutaneous ganglia were seen in different parts of the body; and, at the same time, there was a stiffness of the joints which, to a marked degree, limited his general mobility. The ganglia in the pelvic gluteal regions and in the axillae were palpable. There had been no other illness. Two grown-up sisters were in good health; two died when a month old.

Patient stated that he smoked moderately; did not drink, but formerly had moderately. He denied syphilis. At the time of the medical examination he walked with the aid of a primitive prosthesis,—a wooden leg placed under the bent knee. Joints were susceptible to weather change.

Examination showed a man above average height, strongly built, a little undernourished. The mucous tissues were of a pale pink tint. Red autographism appeared rapidly and as rapidly disappeared. Thyroid gland was of normal size; the regional lymphatic glands were not enlarged; the heart accents were dull; lungs normal. The left leg was somewhat atrophied when compared with the right; on the dorsal surface were seen areas of intense pigmentation of pale violet color. The left leg was flexed at the knee joint at an angle of 115 degrees, with slight subluxation. The skin of the foot and leg was dry, and in places scaly. On the left thigh in the region of the biceps, under the skin, was seen a compact ganglion adherent to the tendon. The tendon itself appeared to be of greater compactness than usual. Extending upwards along this tendon, at about eight centimeters from one another, under the skin, were located compact ganglia of the size of a sixpence. The flexor tendons of the leg were indurated, the popliteal space was thickened and could not be palpated. The tendons of the sartorius and neighboring group were much hardened and thickened, resembling a compact band three to

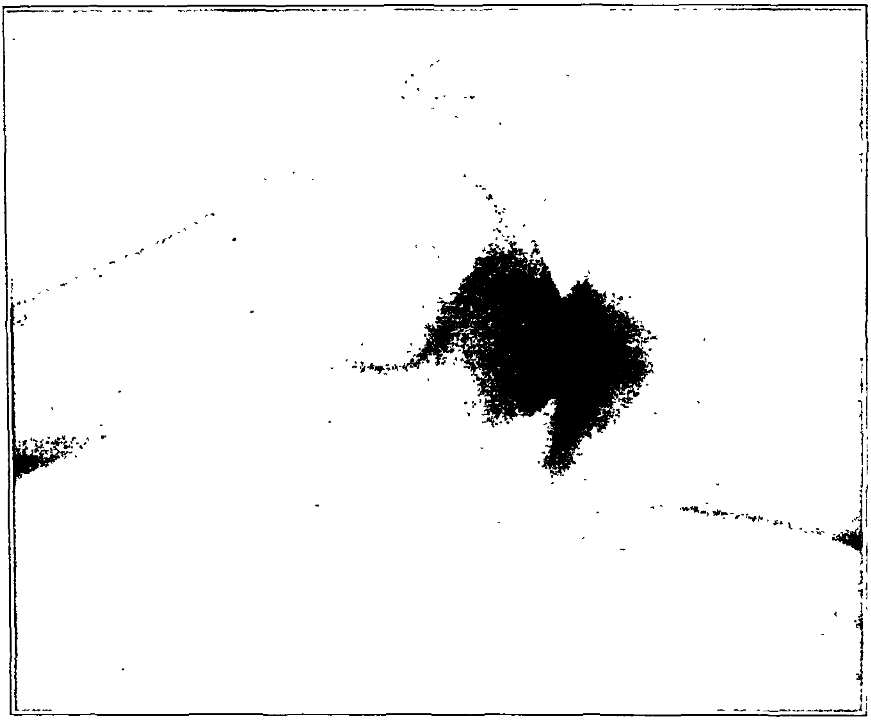

FIG. 1

four centimeters wide, extending one centimeter upward. In the region of the left adductor tendon and at the outer end of Poupart's ligament, were two ganglia the size of a penny. Along the adductors and vastus internus and rectus femoris of the right leg were found several ganglia. At the distal end of the tendons of the sartorius and gracilis on the right was a hardened area about five to seven centimeters long. Upon abduction of the femur there was pain in the location of the calcium ganglia, and the skin adherent to them was noticeably stretched, limiting the abduction, especially on the right side. Calcium ganglia about four centimeters in diameter were found between the gluteal muscles on both the right and left sides. The left knee showed scarcely perceptible motion. Both hands could be lifted above a horizontal line only with difficulty, the left less than the right. Under the lower angle of the right scapula a part of the latissimus dorsi was considerably hardened. The mobility of the other limbs was normal. There was slight sensitiveness of the spine to mild percussion, and the motions of the spinal column showed slight limitation, especially in the backward plane.

The soft tissues of the neck showed a somewhat increased firmness, and, according to the patient, there had been bone-like areas which a year before had prevented free motion.

Fluoroscopy showed slight changes in the knee joint of the arthritis deformans type,—shadows, apparently of calcareous deposits, in the region of the anterior crucial ligament; a dispersed crumb-like mass of calcium ganglia in the area of the flexors (See Figure 1); and shadows of different intensity caused by platelets in the areas of calcium deposits, and corresponding in their location to the clinical description. The vertebral column gave evidence of spondylitis deformans in the lumbar region. Roentgenograms of the chest and abdomen disclosed no calcium ganglia. There was no general osseous atrophy. There were no changes in the urine or in the morphology of the blood; negative Wassermann and Meinike reactions.

Biopsy on the exterior surface of the upper third of the left thigh disclosed a gray, compact ganglion of three by three centimeters, rough and adherent to the skin and fascia. A part of the skin was taken together with the tissues surrounding the ganglion.

Histological report of Dr. A. T. Zamkova: "The layer of epithelium covering the surface of the tissue was extremely thinned,—only three or four laminae of epithelial cells. The derma was also very thin (See Figure 2); total absence of stratum granulosum. On the surface was a rather thick accumulation of horn-like lamellae. The papillae were flattened. The skin showed striking changes; the entire tissue of the papillae and the underlying adipose tissue consisted of bundles of compact collagen tissue presenting a uniform structure over the entire extent of the specimen examined. In some sections, over large spaces in this hyalinized tissue the epitenons were completely absent. In others only an insignificant number were preserved and these were elongated, homogeneous, and brightly colored. In other places, especially around the vessels, the structure of the tissues was better preserved, so that one could see the fibrous structure and a sufficiently large number of stretched-out epitenons. In this homogeneous tissue were seen a large number of dilated lymphatic ducts. The walls of the arteries were markedly thickened and hyalinized. At many points of the deeper parts of the specimen were seen deposits of amorphous calcareous salts which appeared first as very fine broken lines, developing into larger masses, so impregnating the tissue that in some places the structure clearly conserved the cell-like texture of the adipose tissue, or the more compact texture of the fibrous tissue. At other places, the appearance of the structure was quite lost and the section seemed to consist of homogeneous matter, penetrated by calcareous salts of a dark blue tint. In one of the areas subjected to calcination was noted a small section of bone-tissue formation. A hyperplasia of the sweat and sebaceous glands was as clearly evident as the acute hyalinization of the connective-tissue derma and subcutaneous adipose tissue."

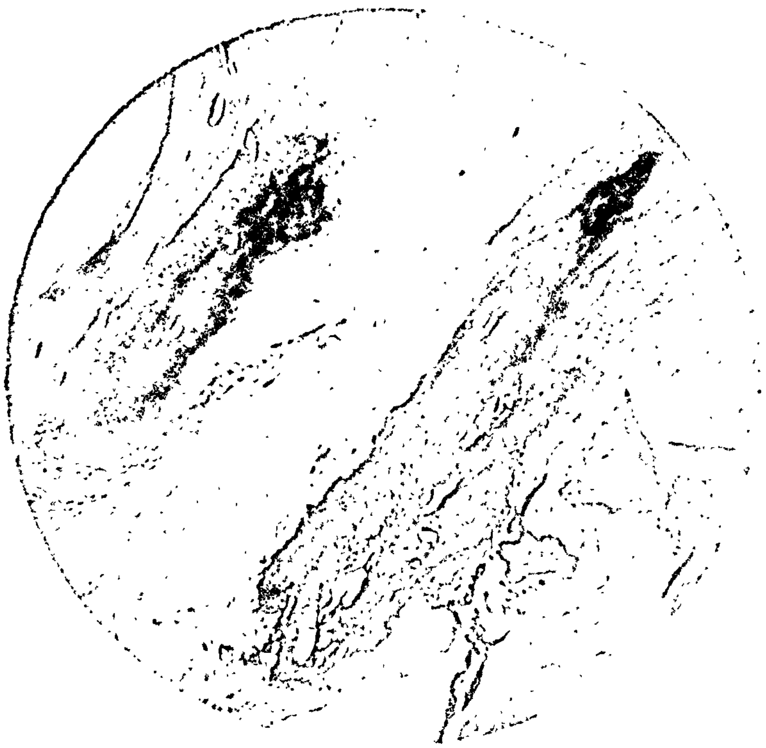

FIG. 2

As literature possesses no convincing information regarding successful treatment of this disease, it was decided in this case to test the method proposed by Rabl, and in our country by Matrossov, for the early stages of rachitic deformities in childhood by means of bloodless reduction. As is well known, the method mentioned is based on the fact that the solution of ammonium chlorid introduced by mouth is apt to produce blood acidosis,

which in turn has its influence on the osseous system by alkalinizing the calcium salts.

Accepting these data, we assumed that if Rabl and Matrossov were right, we might, by creating an artificial acidosis of the blood, produce an absorption of the calcium deposits in the subcutaneous and peritendinous tissues. We also supposed that the calcium ganglia, being tissue less organized and differentiated, would be more susceptible to the action of the acidosis than the true bone. Our attention was chiefly concerned with the peritendinous and pericapsular calcium deposits around the knee joint and within the joint itself, which were causing the permanent flexion of 115 degrees and the nearly complete immobility.

For this purpose we introduced daily by mouth a solution of ammonium chlorid combined, after an interval of one and one-half to two hours, with the application to the extremity of Bier's hyperaemia. Ammonium chlorid was given each day during a seven months' period, with intermissions of seven to ten days each every three to four weeks, to control the absorption of the calcium deposits. For record, before and during the ammonium chlorid treatment, as well as after it, analyses of the blood and urine were made to determine the calcium content. The result of these analyses showed a gradual decrease of the amount of the non-organized calcium in the blood from thirteen and six-hundredths milligrams per 100 cubic centimeters of blood (arithmetical mean) to eight milligrams eleven weeks after the beginning of the treatment; then, as the intermissions were prolonged, there was again a gradual increase, reaching fourteen and nine-hundredths milligrams, when the treatment was stopped. The calcium content of the urine reached twenty and eight-tenths milligrams (arithmetical mean of the daily amount of urine). During the intermission it dropped to thirteen and eight-tenths milligrams, and after the end of the cure was twelve and three-tenths milligrams.

The treatment by ammonium chlorid given internally, also the hyperaemia by the Bier method, were begun on January 15, 1930. On May 11, 1930, the biceps tendon and other flexors of the leg were markedly softer, the mobility of the knee slightly increased, the calcium deposits in the right gluteal region and the right thigh were noticeably softer, and on the outer surface of the thigh were partly disintegrated. All the calcium deposits were reduced in size; the patient also felt the improvement, and was discharged with directions to continue the internal administration of ammonium chlorid.

On July 25, 1930, the calcium ganglion in the left gluteal region was reduced to two centimeters and was more pliable. The biceps tendons and other flexors on the lateral part of the thigh were also noticeably less compact. The mobility of the knee joint showed extension to 155 degrees, flexion to 115 degrees. The patient stated that he had taken the medicine as prescribed for a while, but had been obliged to lessen the daily amount.

Examination seven months later showed the knee joint in flexion of 120 degrees, active mobility of forty degrees; the tendon of the biceps femoris of nearly normal compactness; the semimembranosus and semitendinosus were more compact; here slightly nodulated compact areas with uneven edges, extending upward for about six centimeters, could be felt. In the adductors and the gluteal region the ganglia were a little softer than formerly and smaller in size. The patient himself felt greater ease in the joints; he had continued the ammonium chlorid until the winter.

The record of examination, showing the variations in the amount of calciumin the blood and urine dependent upon the use of ammonium chlorid, coincided with the clinical observations of the resolution of calcium deposits and also the increase in excretion of urine during the time of administration of the medicine, and a diminution during the intermissions.

The records of one case can only add to the records of the pathology and clinical aspect of the already recognized varieties of this disease, since

the calcium deposits appeared soon after an infectious disease, complicated by an oedema spreading over the entire body. In the literature to which we have access there is no case reported with such a pathology, except the Schnitzer case where a strictly limited deposit of calcium ganglia was observed on an elephantiasis-like leg, appearing after repeated erysipelas. Another peculiarity of our case was the arthritic alteration in the knee joint.

There exist several hypotheses as to the nature of the disease, its etiology, and treatment. Versé considers that the main factor of calcinosis interstitialis is only the increased affluence of calcium through the alimentary canal and its decreased discharge, wherein, previous to the deposit of calcium, there was "softening of the collagen tissue, appearing as a consequence of its saturation by plasmatic fluid". Schulze supposes its origin to lie in the disproportion between the accumulation of calcium from nutrition and the power of the bones to assimilate it, with the existence of a simultaneous disorder in the calcium discharge, in which the chief difficulty lies not in the lack of cooperation between the blood and the kidneys, but between the vascular system and the tissue, much as the skeleton is affected by rachitis during the period of growth. Many authors (Selye, Schamoff, Aisenberg, and others) are inclined to ascribe the disturbance in the calcium metabolism in this disease to the glands of inner secretion.

A debatable question also is the process of the changes of the tissues in which the calcium deposits take place. Tilp presumes these changes to be a secondary reaction to the irritation caused by calcium deposits as foreign bodies; Schulze is practically of the same opinion; whereas Versé considers them to be primary, caused by the saturation of the collagen tissue by plasmatic fluid.

Our observations indicate that the wide distribution of oedema has a great influence on the pathology of this disease. In our case the examination of the specimen of the ganglion taken by biopsy showed atrophy and thinning of the epithelium and derma, greater compactness of the subcutaneous adipose tissue, scantiness of epitenons, partial homogenesis, and dilatation of the lymphatic ducts. This must be regarded as the result of compression by the long continued oedema, which rendered the tissue unstable and passive to the deposit of calcium.

Increase of the laminae of the stratum corneum of the lower leg, also its dryness and marble-like coloring, may be considered as analogous to the phenomena accompanying scleroderma described by some authors. Probably in this case the disturbance in the calcium balance results from atrophy of the osseous system under the influence of the compression by the oedema, and the simultaneous disturbance of the function of the kidneys. We believe that the oedema is the direct cause of the changes in the soft tissues, which offer little resistance to the deposit of calcareous salts.

Except as recorded above, there is nothing known in regard to the therapeutics of this disease. Surgical interference is possible and can be

successful only in cases of strictly limited deposits. This can be combined with dietotherapy (Erb). Conservative methods tried by some authors—heliotherapy, electrotherapy (Aisenberg), mechanotherapy (Erb)—gave, at the best, but insignificant results.

The method applied in our case coincides with the data of Rabl and Matrossov in the treatment of rachitis and is worthy of attention and further study. Under suitable conditions, it can be applied to calcinosis interstitialis universalis with satisfactory results.

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PIN FIXATION IN DISLOCATION AT THE HIP JOINT

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From Shriners' Hospital for Crippled Children

The method to be presented is for those cases of dislocation at the hip joint requiring open operation, in which the head of the femur cannot be maintained in the reduced position. If the acetabulum is very shallow, the head of the femur unusually large or misshapen, or the neck of the femur short and distorted, it will often be impossible to keep the femoral head, even temporarily, in apposition with the acetabulum. Often, after a seemingly successful reduction, the head will be found to have slipped upward. This may have taken place during the closure of the wound or the application of the plaster.

In seeking a method to overcome such an accident it was thought that a pin driven through the greater trochanter and into the upper rim of the acetabulum would serve as a practical method of retention. The bone above the acetabular margin is thick and sufficiently dense to firmly hold the pin, and the trochanter in these older patients would add another firm point of fixation. Considering the head, the trochanter, and the place of penetration of the pin into the rim of the acetabulum as a triangle, the component of forces with an upward thrust would be such as to tend to force the pin deeper into the bone. If the pin is sufficiently long so that it will project ten or fifteen centimeters beyond the skin, it can be incorporated in the plaster, thereby reenforcing the fixation. If a short pin is used it can be buried beneath the skin, thereby lessening the danger of infection. The added point of fixation would not be attained and it would be necessary to make a subsequent incision to remove the pin. The pin may pass inside the capsule but care should be taken to avoid penetrating the head of the femur, in order not to injure an already traumatized bone and articular cartilage. It may be advisable to direct the pin so that it will travel outside of the capsule, in order that, in case of an accidental infection, the joint may not become involved.

This method of pin fixation has been successfully applied in six cases. A report of one operation will serve to illustrate the clinical application: Through a Smith-Petersen approach the capsule of the hip joint is exposed and opened. The head of the femur is then reduced to the level of the acetabulum. The greater trochanter is then exposed and a pin driven through it at such an angle that the point will engage in the border of the acetabulum above the head of the femur (Figs. 1 and 2). It will be found that, as soon as the pin gets a hold on the bone of the acetabular rim, there is no tendency to upward displacement of the head. The capsule of the

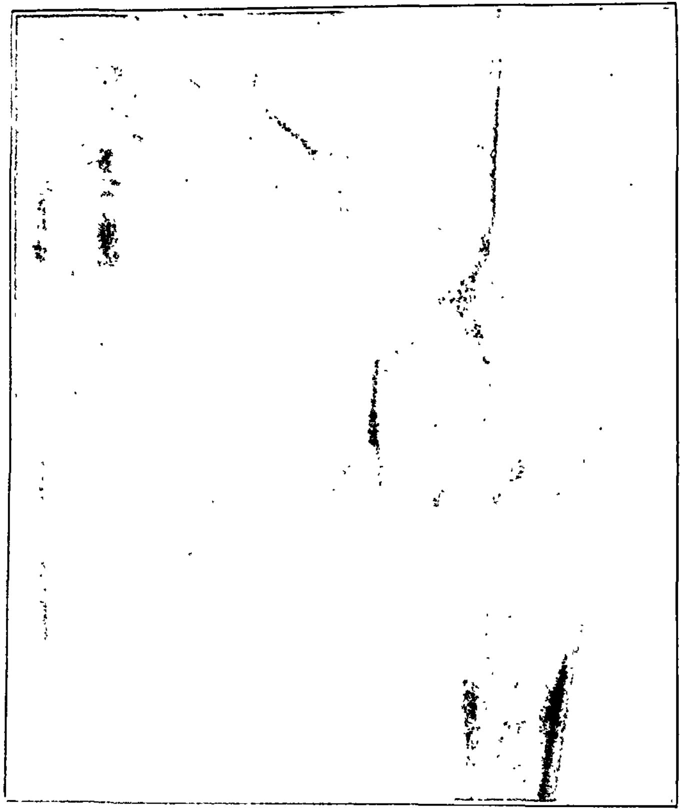

FIG. 1

Roentgenogram showing dislocation at the hip joint with a very shallow acetabulum. Patient is now fourteen years of age. History of anterior poliomyelitis at the age of nine months.

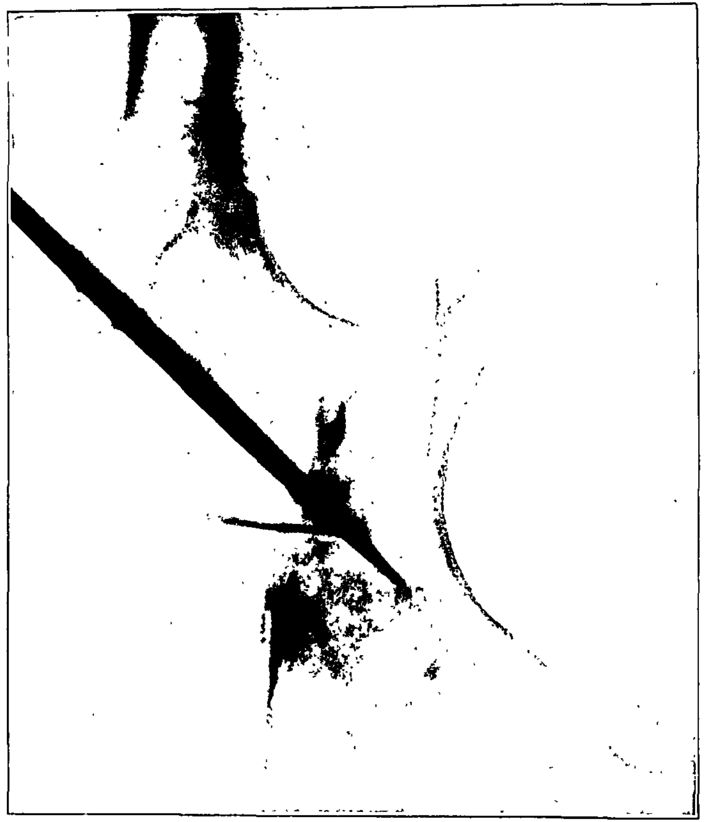

FIG. 2

Roentgenogram after reduction, showing the femoral head held in the reduced position by a pin driven through the trochanter and into the acetabulum. The pin does not penetrate the head. Notice the bone shelf just above the end of the pin.

joint is sutured, after which a bone shelf is constructed above the head. The wound is closed in layers, but in closing the skin it will usually be found necessary to make a cut perpendicular to the line of incision to the pin. The pin is removed when the union between the shelf and ilium is sufficiently firm to prevent upward migration of the femoral head. At least four weeks should be allowed before taking out the pin, and another two or three weeks before the plaster is removed and motion started.

CONCLUSION

In those cases of dislocation at the hip joint in which there is a tendency toward upward displacement after open reduction, the femoral head *may be maintained in position by a pin driven through the greater trochanter and into the upper margin of the acetabulum.*

ARTHROSCOPY OF THE ELBOW JOINT*

A Cadaver Study

BY MICHAEL S. BURMAN, M.D., NEW YORK, N. Y.

From the Service of Dr. Leo Mayer, Hospital for Joint Diseases

It was noted previously that arthroscopy of the elbow joint was not possible. Since then, we have had cause to revise our opinion, and have visualized the anterior compartment of the elbow joint excellently, by means of an anterior puncture, horizontally directed. Puncture may be either lateral or medial, at the base of the lateral or medial epicondyle, respectively, either with the sharp-pointed trocar through the unbroken skin, or with the dull-pointed trocar through a nick in the skin. The needle is pointed downward as it is pushed in. The joint is easily distended with fluid, preferably by the gravity method, not more than ten to fifteen cubic centimeters being required to distend the joint to a moderate degree. Puncture and distention are best made with the elbow in moderate flexion, since in extension the anterior compartment is rendered taut and reduced in its capacity.

Ten joints have been examined in the cadaver to determine arthroscopically the possibilities of vision. In the *opened joint*, it is noted that the entire anterior compartment can be seen well through the arthroscope, the medial part best through a lateral puncture, and the lateral through a medial puncture. The radiohumeral joint, the humero-ulnar joint, the coronoid fossa, the coronoid process, the head of the radius, the trochlea and capitellum of the humerus, all can be seen very clearly. The head of the radius is observed rotating on pronation and supination of the forearm; the coronoid process of the ulna is seen moving toward the trochlea of the humerus on flexion and away from it on extension of the elbow. The coronoid fossa is not always delineated clearly, since it may be occupied by fat and synovia. The elbow contains a disproportionate amount of fat and synovia which may easily block vision of structures.

The dangers of the procedure are obvious, especially if the trocar is pointed upward. The large radial and ulnar recurrent vessels supply the capsule of the joint and are well seen in injected cadavera. The relatively thin brachialis anticus muscle separates the brachial vessels and median nerve from the joint. Therefore it is necessary to keep the trocar, preferably a dull-pointed one, always directed downward.

*Most of this work was done in the Mortuary of the New York Post-Graduate Medical School and Hospital through the courtesy of Dr. Leo Mayer.

The closed joint. The bases of the medial or lateral epicondyles are easily palpated, and the trocar, directed anterohorizontally and somewhat downward, is inserted. The medial puncture is best for joint visualization. The entire joint may be examined through this one puncture, though, at times, only vision of the radiohumeral joint may be permitted. On withdrawing the trocar slowly, an advancing fat wall is noted,—the fat of the medial aspect of the joint. Usually, however, the humero-ulnar joint is also seen through the medial puncture. With the needle at twelve o'clock, only fat and synovia are seen; with the needle at seven o'clock (right side) or at five o'clock (left side), the entire joint can be visualized,—not in one field of vision, but usually in three or four. No traction is necessary. The head of the radius can be seen to rotate upon the capitellum of the humerus on rotation of the forearm; in a field of vision medial to the former, the humero-ulnar articulation can be examined and the coronoid process seen to move on flexion and extension as previously noted. The radio-ulnar joint is not seen either in the closed or in the opened joint. It is difficult to see the coronoid fossa sometimes; it has also been difficult to see the lateral ridge of the trochlea. Synovia and fat are well seen and sometimes may be so prominent as to obscure bony landmarks. The epicondyles are not in the field of vision, since they are extracapsular. Nothing of the posterior compartment of the elbow can be seen.

SUMMARY

The elbow joint is added to the list of major joints which can be visualized directly by means of the arthroscope[1]. A new puncture, an anterohorizontal one, medially or laterally placed, is described. The blunt trocar is considered best for use.

1. BURMAN, M. S.: Arthroscopy or the Direct Visualization of Joints. An Experimental Cadaver Study. J. Bone and Joint Surg., XIII, 669, Oct. 1931.

LONGITUDINAL FRACTURES OF THE PATELLA

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*Assistant Adjunct, Hospital for Joint Diseases***

The purpose of this paper is to call attention to longitudinal fractures of the patella. These fractures, although thought a great rarity are, in the belief of the writer, rather common, and as a rule unrecognized.

Modern methods of diagnosis and treatment of fractures have progressed tremendously in recent decades. Anderson, in 1898, describing a specimen of transverse fracture of the patella, said: "Although not of very frequent occurrence, yet fracture of the patella is an accident that is sure to happen once or twice in the life of every surgeon who is in practice for any length of time (and probably oftener in the country), and it is an accident which, according as it is well or ill treated, has before now made or marred a practice".

How old-fashioned these words seem today!

Nowadays every house surgeon has had the opportunity of treating some transverse fractures of the patella during the period of his training. However, it is quite unusual, even in the experience of his elders, to have seen a case of longitudinal fracture of the patella.

Literature on this fracture is scarce, although the first description of longitudinal fracture of the patella was made by Guilelmo di Saliceti as early as the thirteenth century. In 1687 Van der Wiel reported a definite case of this fracture. In 1875 Wohlers, in his dissertation on longitudinal fractures of the patella, collected fifteen cases with two cases of his own. Just a few further reports on this subject appeared at the end of the nineteenth century.

The recognition of this condition was greatly facilitated by the discovery of roentgen rays. In 1906 Meyer published an excellent work on longitudinal fractures of the patella, adding seven new cases. More recent literature on fractures scarcely mentions this uncommonly known fracture.

Scannell found, among 38,246 classified fractures of all types in the Boston City Hospital, during forty-two years of its existence, 667 fractured patellae. This put fractures of the patella fourteenth in order of frequency, and made them one and eighty-three hundredths per cent. of all fractures.

Corner, analyzing 504 cases of fractured patellae admitted to the St. Thomas's Hospital between 1890 and 1907, found: transverse fractures, eighty-five per cent.; comminuted fractures, ten per cent.; oblique fractures, four per cent.; compound fractures, one per cent. No longitudinal fractures were mentioned.

*Service of Dr. Percy W. Roberts.
**Service of Dr. Leo Mayer.

There were thirty-five fractured patellae among 1,393 treated fractures in the more recent statistics of Plagemann, or two and fifty-one hundredths per cent. of the total. During the preparation of his classification, Plagemann observed no longitudinal fracture of the patella although later two cases were seen by him.

Dr. Clay Ray Murray, in the vast clinical material of the Fracture Departments in the New York Presbyterian Hospital, could recall seeing only one case of longitudinal fracture of the patella.

The newer text-books on fractures either omit longitudinal fracture of the patella entirely or dispose of it in a few words. Scudder states: "a longitudinal fracture of the patella may occur. Following the injury to the knee it should not be overlooked. A persistent joint effusion or recurring joint effusion from slight injuries or overexertion may suggest the true condition to be a longitudinal fracture of the patella and not primarily a chronic arthritis."

Speed, in his text-book, shows a picture of a typical longitudinal fracture of the patella over the junction of its outer and middle quarters and says: "These fractures usually involve the outer portion of the bone and the outer fragment is displaced outward, pulled by the vastus externus insertion".

Early in 1929, the writer treated his first case of longitudinal fracture of the patella. The late Dr. Reginald Sayre, when the roentgenograms of this case were shown to him by the writer, admitted that he had never seen a similar fracture of the patella and considered it a very rare and unusual occurrence. Since that time, the writer has carefully studied all cases of injured knees coming under his care, being on the look-out for this type of fracture. To his great surprise he was able to accumulate, in a period of approximately two years, thirteen cases, either treated by him or by some of his colleagues,—nine of which were definite longitudinal fractures of the patella with typical location of the line of the fracture on the junction of the middle and outer quarters of the patella.

On January 3, 1930, Dr. P. Dineen presented a case of a longitudinal fracture of the patella at the meeting of the Surgical Section of the New York Academy of Medicine. This case was evidently considered as extremely rare by all those present, none of whom could recall ever having seen a similar case. The writer, in the discussion of Dr. Dineen's case, then presented his series of longitudinal fractures of the patella.

DESCRIPTION OF THE CASES

CASE 1. Miss A.H., twenty-eight years old, applied for treatment at the Clinic of the Hospital for Ruptured and Crippled on October 28, 1929, complaining of pain and stiffness in the left knee. The night before, while walking downstairs, her right heel caught in the edge of a stair and she fell, landing on her left knee with the leg in acute flexion, so that the toes of the left foot were on the upper stair and the knee on the stair below. She was hardly able to walk following the accident.

Examination revealed an abrasion over the lower tip of the left patella about the size of a nickel. The patient walked with a slight limp. Moderate effusion was present in the knee joint. There was marked linear tenderness, strictly localized in a longitudinal

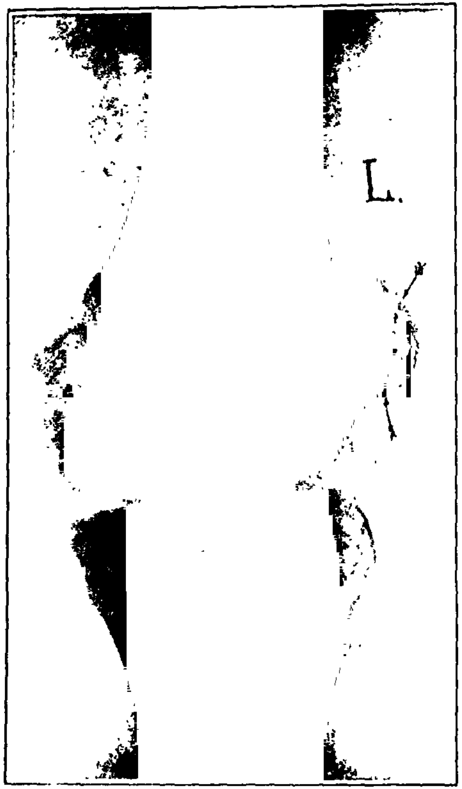

FIG. 1-A

Case 1. Posterior anterior view of the left knee taken with slight external rotation. (All of the roentgenograms of the posterior anterior view in this series are printed in reverse.) The line of fracture is clearly demonstrable at the junction of the middle and outer quarters of the patella.

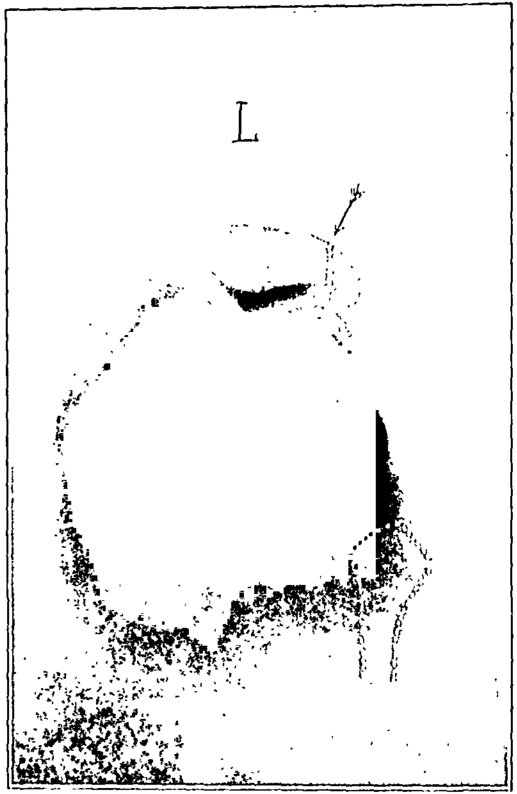

FIG. 1-B

Same patella taken with the flexed knee. Patient lying on her abdomen with the film beneath the thigh. (Fibula retouched.)

FIG. 1-C

Lateral view of the same knee taken in routine technique on the same day, showing no evidence of fracture. This roentgenogram illustrates that longitudinal fracture of the patella cannot be demonstrated in this particular view. That is the reason why this fracture may easily be overlooked.

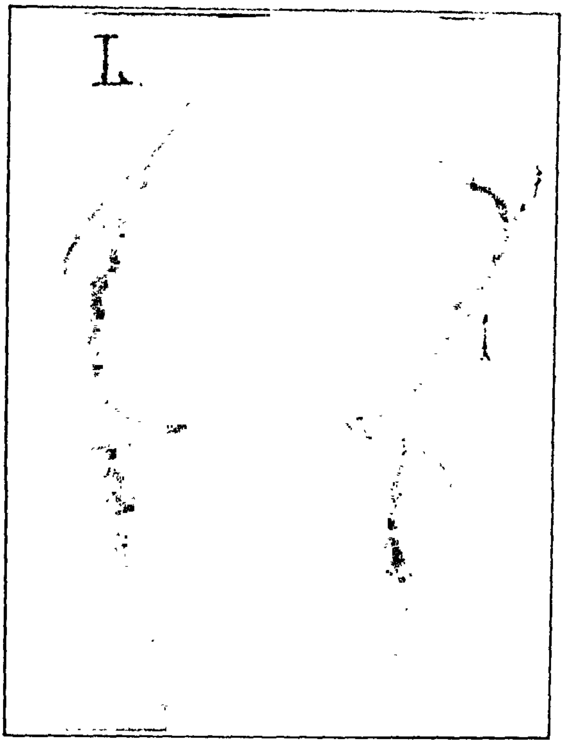

FIG. 1-D

Case 1. Same patella taken with the same technique as Fig. 1-A, seven months later, showing bony union of the fragments.

direction, over the lateral part of the left patella. The motion of the left knee joint was considerably limited, the angle of greatest extension being 180 degrees, angle of greatest flexion, 140 degrees. The circumference over the middle of the patella of the right knee was thirty-eight centimeters while the left knee was thirty-nine. The roentgenograms taken on the same day in routine technique (anterior posterior and lateral views) were reported as showing considerable soft-tissue swelling but no bony abnormalities. On the basis of clinical findings, a longitudinal fracture of the left patella was suspected and new roentgenograms with a special technique for the patella were ordered. These showed a typical longitudinal fracture of the patella over the junction of its middle and outer quarters (Figs. 1-A and 1-B).

October 30, 1929: The left knee was aspirated and thirty-five cubic centimeters of reddish-brown fluid obtained. Knee was strapped with adhesive plaster for about one week.

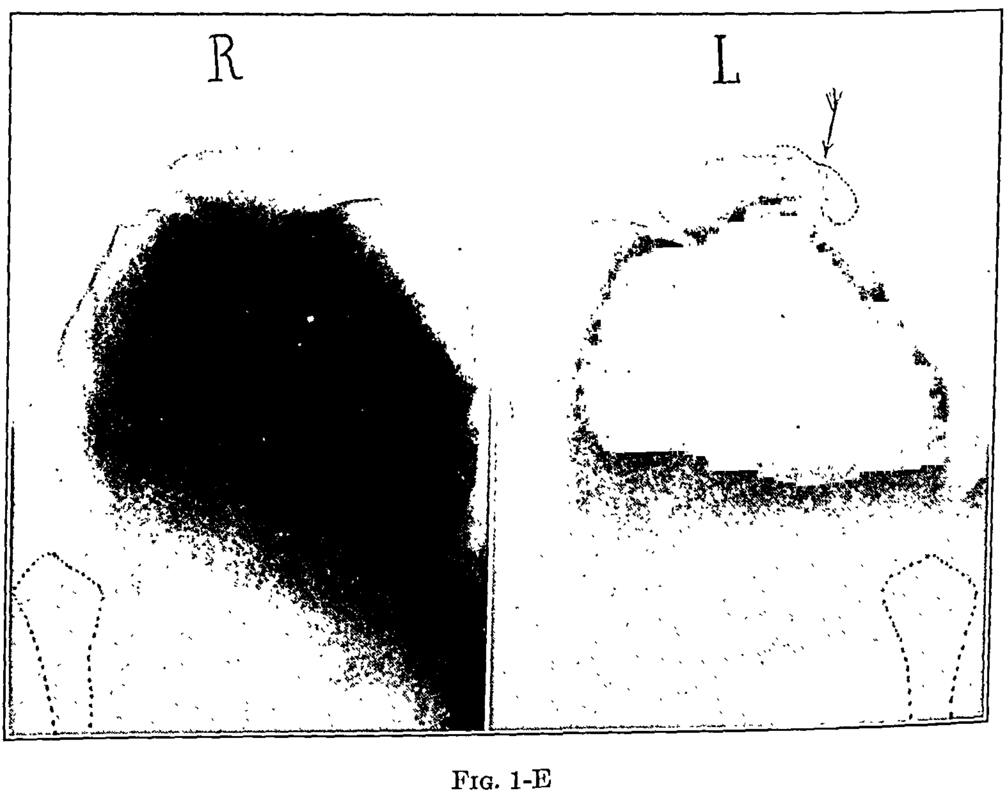

FIG. 1-E

Case 1. Both patellae with flexed knees seven months after the injury. The line of fracture of the left patella is still clearly demonstrable. (Outline of both fibulae retouched.)

November 8, 1929: The patient stated that she felt much better. The tenderness along the line of fracture was still present. There was some reaccumulation of fluid in the left knee joint. On aspiration, sixteen cubic centimeters of red, wine-colored fluid was obtained. The knee was again strapped with adhesive plaster and patient was permitted to walk.

November 15, 1929: Seven cubic centimeters of yellow fluid was aspirated from the left knee joint. Extension in the left knee was possible to 180 degrees and flexion to 110 degrees. Strapping was removed and physical therapy started.

November 22, 1929: There was slight effusion still present and the patient complained of stiffness in the left knee joint, especially when going up and downstairs. The flexion was possible to thirty-five degrees, about ten degrees less than in the right knee. There was still some tenderness along the line of fracture. For the fourth time the knee was tapped and seventeen cubic centimeters of yellow, slightly reddish fluid with fibrinous flakes aspirated.

FIG. 2-A

Case 2. Typical location of the longitudinal fracture. This roentgenogram was taken with the knee acutely flexed, patient kneeling on the film. (Patella retouched.)

November 29, 1929: About four and a half weeks after the injury there was no evidence of intra-articular effusion and only a slight tenderness along the line of fracture could be elicited. The range of motion of the left knee was normal and the patient felt no pain except for a slight discomfort while walking.

December 6, 1929: The patient was perfectly comfortable except for occasional aching pain in the left knee. She walked a mile every day without discomfort. There was no effusion in the left knee and motion was perfectly free and painless. The tenderness along the line of fracture had completely disappeared. Patient was discharged as cured.

When seen again on May 28, 1930, (seven months after the injury) the patient volunteered the information that she felt perfectly well. Her left knee was normal and the roentgenograms taken on that date showed evidence of bony union at the site of the fracture but the location of the fracture could still be seen (Figs. 1-D and 1-E). The roentgenograms of the right patella, taken for comparison, showed no abnormality.

CASE 2. Dr. R.R., fifty-three years of age, in the spring of 1929 slipped, striking his knee against the desk. He was treated at first by Dr. L. Saltzman, who found considerable effusion in the right knee, and marked tenderness over the lateral aspect of the patella. Aspiration of the knee was suggested but was refused by the patient. Roentgenograms showed a typical longitudinal fracture over the lateral border of the right patella (Figs. 2-A and 2-B). The patient was treated with adhesive strapping and remained at his work, which was that of executive officer at a hospital.

Several weeks after the injury the patient was treated at the writer's office. At that time there was a normal range of motion in the right knee joint, no evidence of intra-articular effusion, and no tenderness over the fractured patella. Unfortunately, detailed clinical data is lacking in this case. When seen in May, 1931, the patient volunteered the information that his knee did not cause him any discomfort.

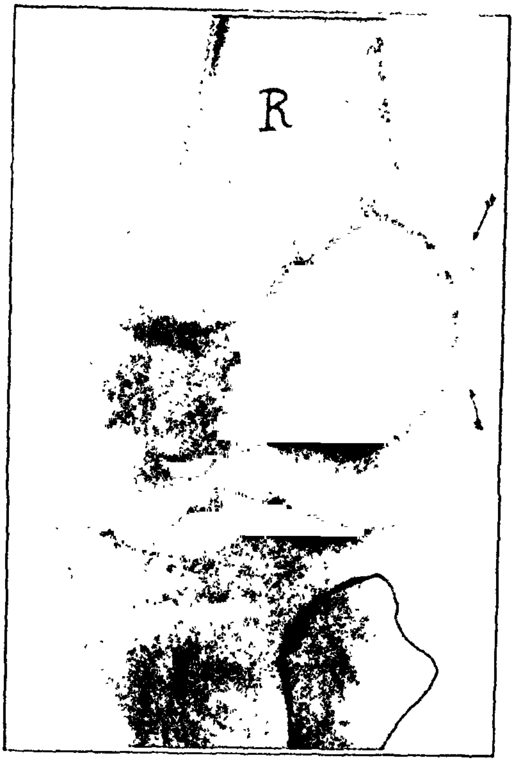

FIG. 2-B

Case 2. Same patella in posterior anterior view with slight external rotation. (Fibula retouched.)

FIG. 2-C

Routine lateral view of the same knee taken on the same day. No evidence of fracture can be detected in this view.

CASE 3.* Mr. E. B., thirty years old, a laborer, on May 7, 1929, fell a distance of twenty feet, landing on both knees and hands, and striking his face against the ground.

On examination, four days later, there was a marked swelling on the right knee and complete limitation of motion in that joint. The right knee was held at an angle of about 170 degrees. There was a marked intra-articular effusion present and the patella was very tender on palpation. Due to this injury there was also a traumatic synovitis of the left knee joint, fracture of the right carpal scaphoid bone, and flattening of the bridge of the nose.

May 11, 1929: On aspiration of the right knee eight cubic centimeters of bloody fluid was obtained. The knee was tightly bandaged. Roentgenograms showed longitudinal fracture of the right patella over the junction of the middle and outer quarters (Fig. 3). No roentgenograms of the left knee were taken.

May 14, 1929: On aspiration of the right knee joint forty cubic centimeters of blood-tinged fluid was obtained and a plaster-of-Paris casing applied to the right knee.

May 18, 1929: The casing was removed due to discomfort. Twenty cubic centimeters of fluid aspirated from the right knee joint and strapping applied. Patient was allowed to walk.

May 20, 1929: Diathermy to the right knee every other day, with tight bandaging after the treatment, was advised.

August 1, 1929: Patient returned to work as a laborer. At that time the extension of the right knee was possible to 180 degrees, flexion to ninety degrees.

November 1, 1929: Patient was discharged, as compensation case. There was no pain in the right knee and the range of motion was between 180 degrees' extension, and about fifty degrees' flexion.

*This case was treated by Dr. S. Ritchie and examined only once by the writer. The writer wishes to express his indebtedness to Dr. Ritchie for his kind permission to include this case in this series.

CASE 4.* Mr. G.P., a truckman, thirty-five years old, was first seen on consultation by Dr. A. S. Griswold as a compensation case, on June 16, 1927.

On June 14, while unloading a truck beside a platform, the patient slipped and fell, striking the left knee directly against the platform. He was unable to walk at first, but later managed to with difficulty. Patient complained of pain in the left knee and walked with the aid of crutches.

June 16, 1927: On examination there was found a moderate joint effusion and some periarticular swelling over the left patella, but no ecchymosis. There was an acute tenderness, sharply localized over the lateral border of the left patella. Roentgenograms showed a vertical fracture of the left patella over the junction of the middle and outer quarters (Fig. 4). No roentgenograms of the right knee were taken.

July 16, 1927: Patient was treated by his family physician with rest and ice bags. There was still some effusion in the left knee joint with tenderness along the line of fracture, and some weakness of the leg, particularly of extension. Patient was given physical therapy and encouraged to walk.

July 25, 1927: Patient had ninety degrees' motion in his left knee joint and walked well with a cane.

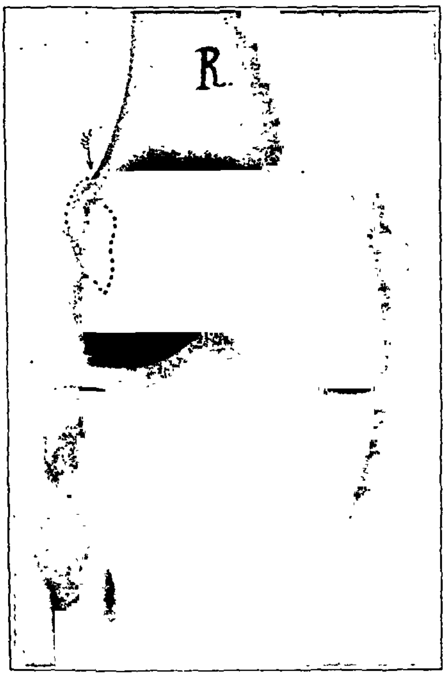

FIG. 3

Case 3. Straight anterior posterior view of the right knee showing a typical longitudinal fracture of the patella with slight upward displacement of the lateral fragment (lateral fragment retouched). The presence of fracture can be easily overlooked in this view the same as on Fig. 4.

FIG. 4

Case 4. Posterior anterior view of the left knee with longitudinal fracture of the patella over its outer and middle quarters (retouched).

*The writer wishes to express his appreciation to Dr. A. S. Griswold for the use of the above case in this series.

August 4, 1927: The patient walked without a limp and with no support. The knee motion was complete.

August 8, 1927: The patient had completely recovered and returned to his former work.

CASE 5.* Mr. M. S., thirty years old, while riding in a taxicab, was thrown against an iron seat in front of him, striking both knees, evidently with his knees flexed. The accident occurred in November, 1929. The right knee became painful and swollen. The patient had been kept in bed for two and a half weeks, applying wet dressings to his right knee for the first ten days.

His right limb was then placed in a plaster-of-Paris casing. This was split and for about two months he received baking. The patient then feeling pretty well, tried to play tennis, in which game he was expert. The right knee became swollen.

During the period of his illness, the injured knee had been tapped on several occasions. At the first aspiration, bloody fluid was obtained. Subsequently the fluid was clear.

In June, 1930, the patient consulted Dr. S. Kleinberg, whose notes read as follows: "The patient is in good condition. He walks without a limp. The right knee appears

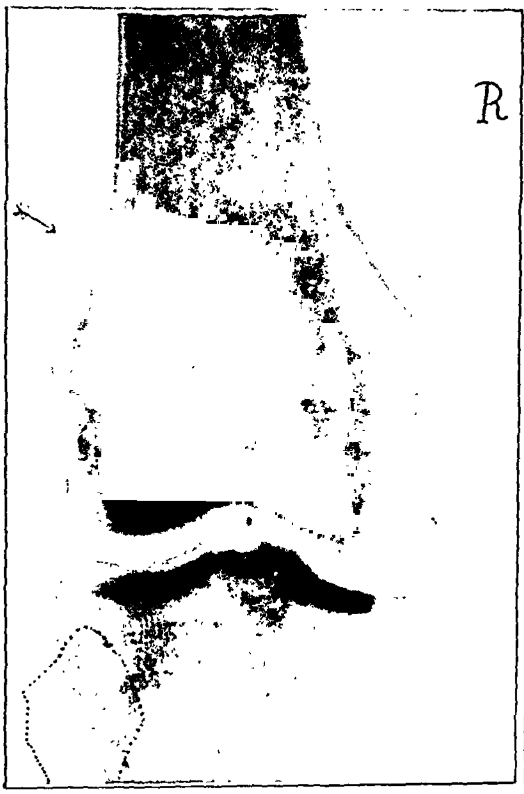

FIG. 5-A

Case 6. Anterior posterior view of the right knee taken with slight external rotation showing a typical longitudinal fracture of the patella. Despite three months following the injury, the gap between the fragments is still clearly demonstrable without evidence of callus formation. There is evidently only fibrous union of the fragments. (Fibula retouched.)

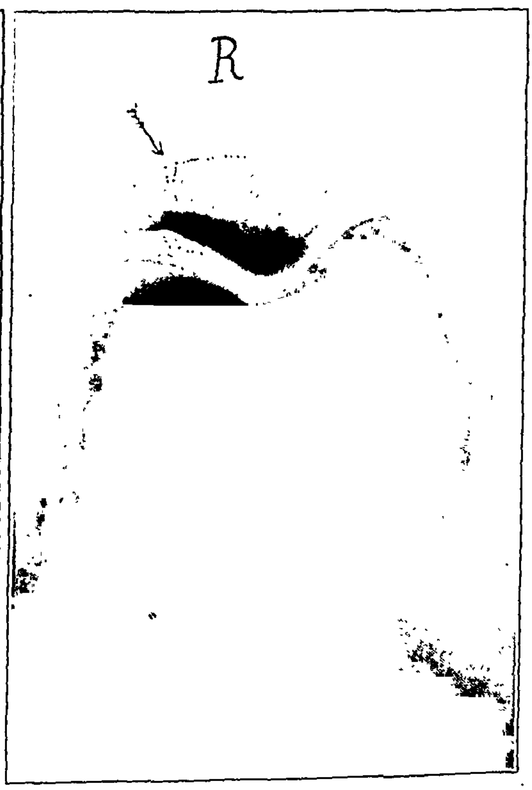

FIG. 5-B

Same patella taken with flexed knee. This roentgenogram was taken with the patient kneeling over the film which was beneath his tibia.

*The writer wishes to express his appreciation to Dr. S. Kleinberg for the use of the above case in this series.

normal. The hollows on either side of the patella are visible. Motions in the knee are free. There is no effusion into the joint. There is no tenderness to pressure over any of the bony prominences. There is no abnormal anteroposterior, lateral, or rotary motion in the knee. There is a little thickening in the region of the infrapatellar pad of fat. The x-ray picture shows a vertical fracture of the patella. The fracture line is through the outer third of the patella. The smaller outer fragment has been displaced upward but appears to be united to the body of the patella. An x-ray picture of the opposite knee is negative."

Evidently, in this case, there was a typical longitudinal fracture of the right patella as a result of the injury sustained during the automobile accident in November, 1929. The true nature of the condition had remained unrecognized until June, 1930, when the patient was examined by Dr. S. Kleinberg, and roentgenograms with a special technique for the patella were taken.

Unfortunately the roentgenograms in this particular case could not be obtained.

CASE 6. Mr. M.O'N., laborer, twenty-eight years of age, was hit by an iron press, weighing about three hundred pounds, on December 26, 1928. The press fell on the patient's back, while he was crawling on hands and knees on the floor. He was taken to an out-of-town hospital, where, according to his information, he was treated for a "dislocation of the right hip and injury to the right knee and back".

On April 22, 1929, he was seen by the writer in consultation with Dr. D. Sohn, as a compensation case. On examination at that time there was found a slight limitation of

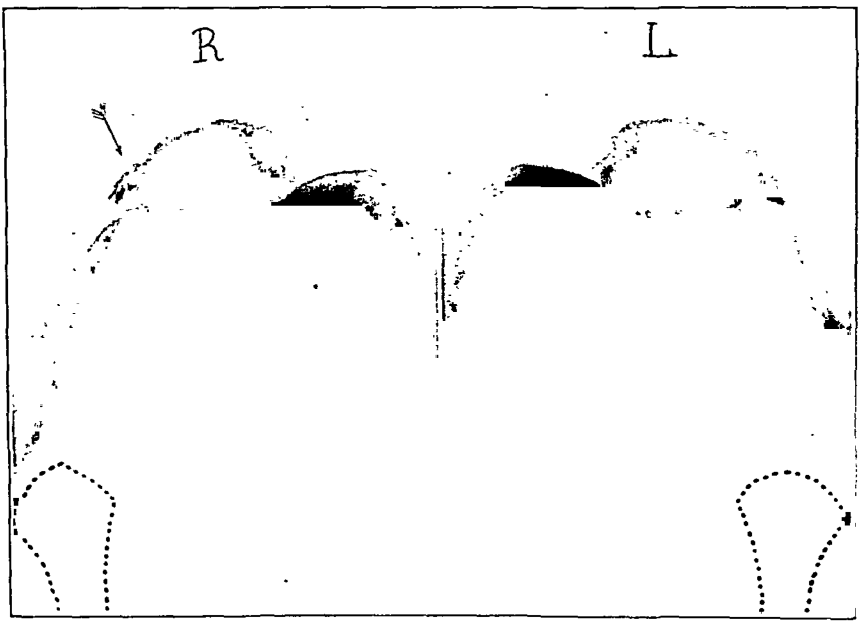

FIG. 6-A

Case 7. Both patellae taken with the flexed-knee technique. The arrow points to the line of the fracture of the right patella clearly visible on the films and not quite distinct on the plates. Note irregularity of the anterior surface of the patellae and marked osteo-arthritic changes.

motion in the right hip joint. The right knee had a perfectly normal and painless range of motion. There was no effusion in the right knee joint. A slight vertical ridge could be palpated over the lateral part of the right patella, but there was no tenderness.

The roentgenograms (about three months after the injury) showed a united fracture of the left transverse process of the third lumbar vertebra, arthritic changes in the right hip joint, and a typical longitudinal fracture of the right patella over the junction of the outer and middle quarters without any evidence of bony union (Figs. 5-A and 5-B).

CASE 7.* Miss E.B., a colored cook, forty-two years old, slipped on a grapefruit seed on February 24, 1931, and fell on her right side, landing on the concrete floor on her right elbow and right knee, with the right leg flexed. The patient complained of pain in her back and right knee, the latter becoming swollen and stiff. She remained in bed for two days and after that returned to her work.

She was seen at the Night Clinic at the Hospital for Joint Diseases on February 26, 1931. Upon examination, there was found some tenderness over the lumbar spine, particularly the third and fourth lumbar vertebrae. The right knee showed the presence of some effusion, but no evidence of fracture. The roentgenograms of the right knee (routine technique) were reported as showing osteo-arthritic changes without evidence of fracture.

On February 27, 1931, the patient was examined by the writer, who found a slight effusion in both knees, particularly the right. There was a severe tenderness strictly localized in a vertical direction along the lateral border of the right patella. The other

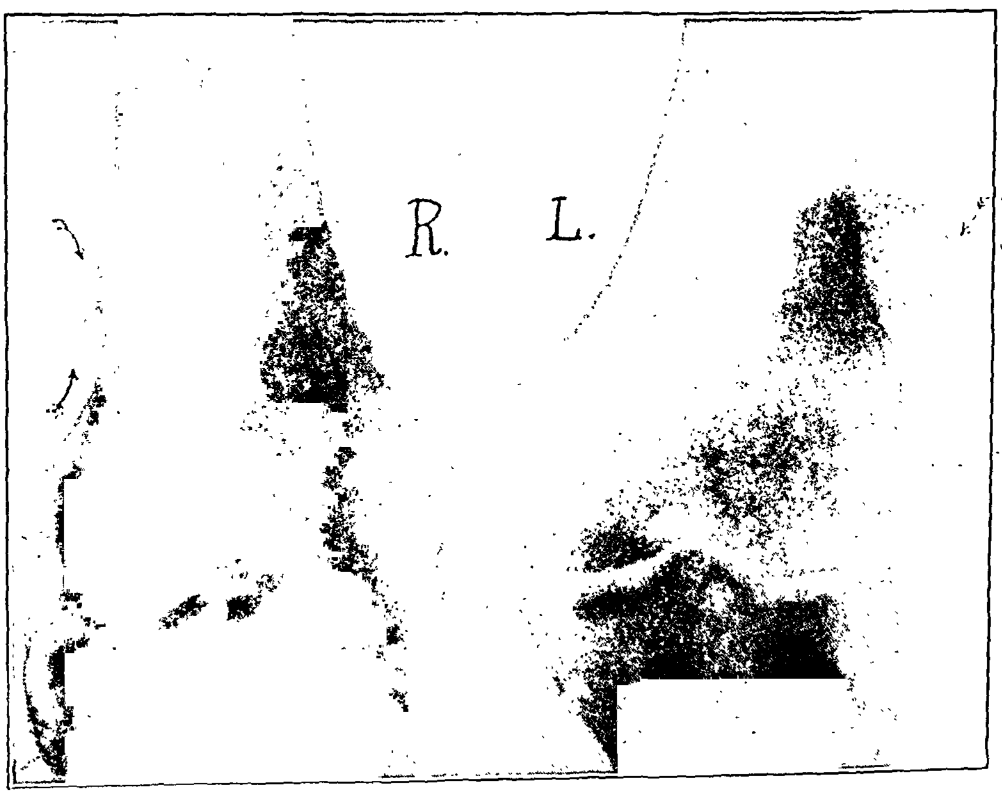

FIG. 6-B

Case 7. Posterior anterior view of both knees taken with slight external rotation. The typical longitudinal fracture of the junction of the outer and middle quarters of the right patella is clearly demonstrable. The arrow on the left patella points to the outer part of it which may be considered an accessory center of ossification or possibly a result of proliferative osteo-arthritic changes.

*From the service of Dr. H. C. Frauenthal, Hospital for Joint Diseases.

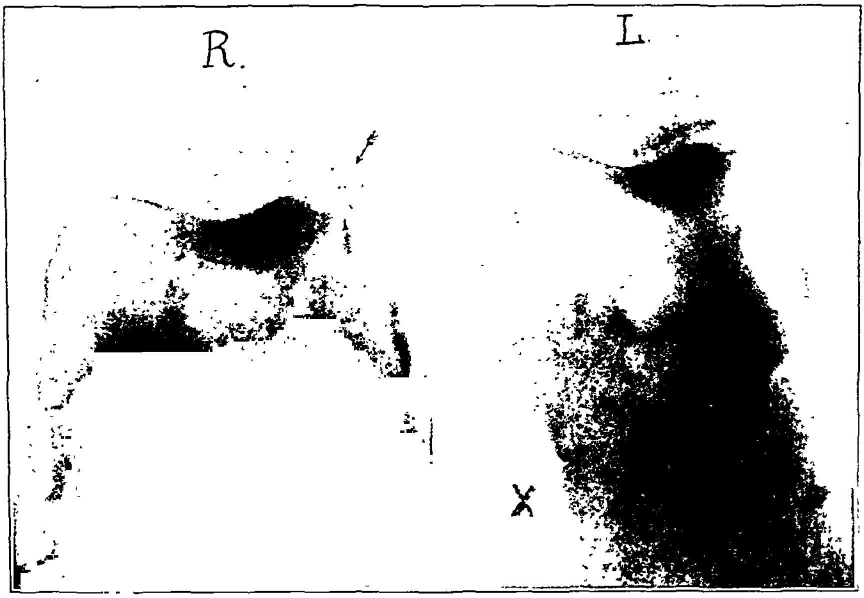

FIG. 7-A

Case 8. Both patellae taken with flexed-knee technique. Note free irregular fragment over the outer border of the right patella. "X" shows the location of the head of the fibulae.

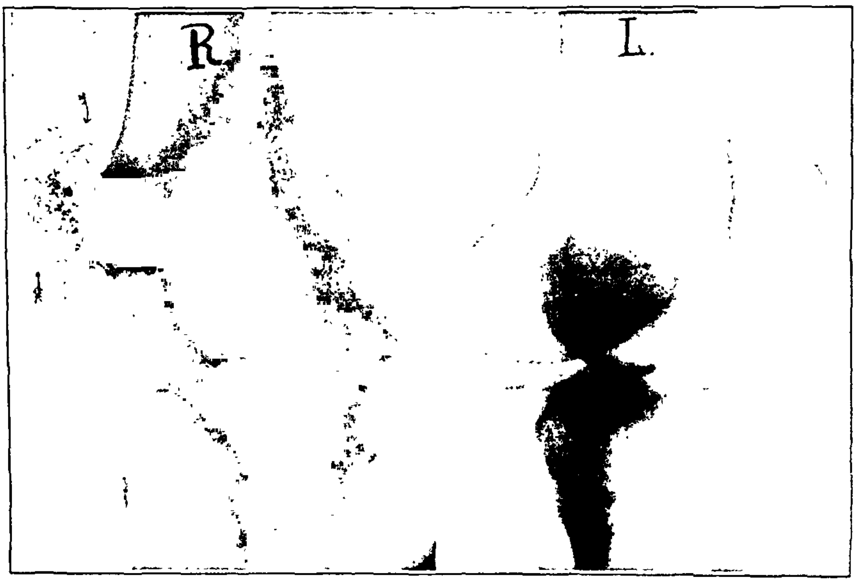

FIG. 7-B

Case 8. Posterior anterior view of both knees. There is too much external rotation of the leg; therefore this view appears more like a lateral view. Note the large fragments over the outer border of the left patella with marked osteoarthritic changes.

parts of the patella were not tender. There was no enlargement of the right knee, the circumference of both knees being thirty-eight centimeters at the middle of the patella. The angle of greatest extension of the right knee was 180 degrees, the angle of greatest flexion, seventy-five degrees, with considerable pain on attempt at further flexion. There was no loss of power of active extension in the right knee nor was it painful.

Diagnosis of longitudinal fracture of the right patella was made upon the clinical findings. The new roentgenograms, taken with a special technique for the patella confirmed it.

February 27, 1931: On aspiration eighteen cubic centimeters of transparent, yellow fluid with a few fibrinous flakes was obtained from the right knee. Strapping was applied.

March 3, 1931: Some reaccumulation of fluid in the right knee joint. Considerable tenderness over the lateral border of the right patella was still present, but less than on the previous examination. The patient had been in bed because of pain in the back, but the knee had given her comparatively little discomfort. The blood Wassermann and gonococcal complement-fixation tests were reported negative.

March 6, 1931: Strapping was removed. The patient walked with a slight limp. There was still a slight effusion in the right knee joint and marked tenderness over the lateral border of the right patella. Physical therapy was given three times a week.

March 12, 1931: The report of the examination of the joint fluid, kindly submitted by Dr. D. H. Kling, reads as follows: "Eighteen cubic centimeters of a turbid, greenish fluid with some fibrin. Icterus index 4.1. White count 800 cells per cubic millimeter. Ten per cent. polymorphonuclears; seventy per cent. lymphocytes; twenty per cent.

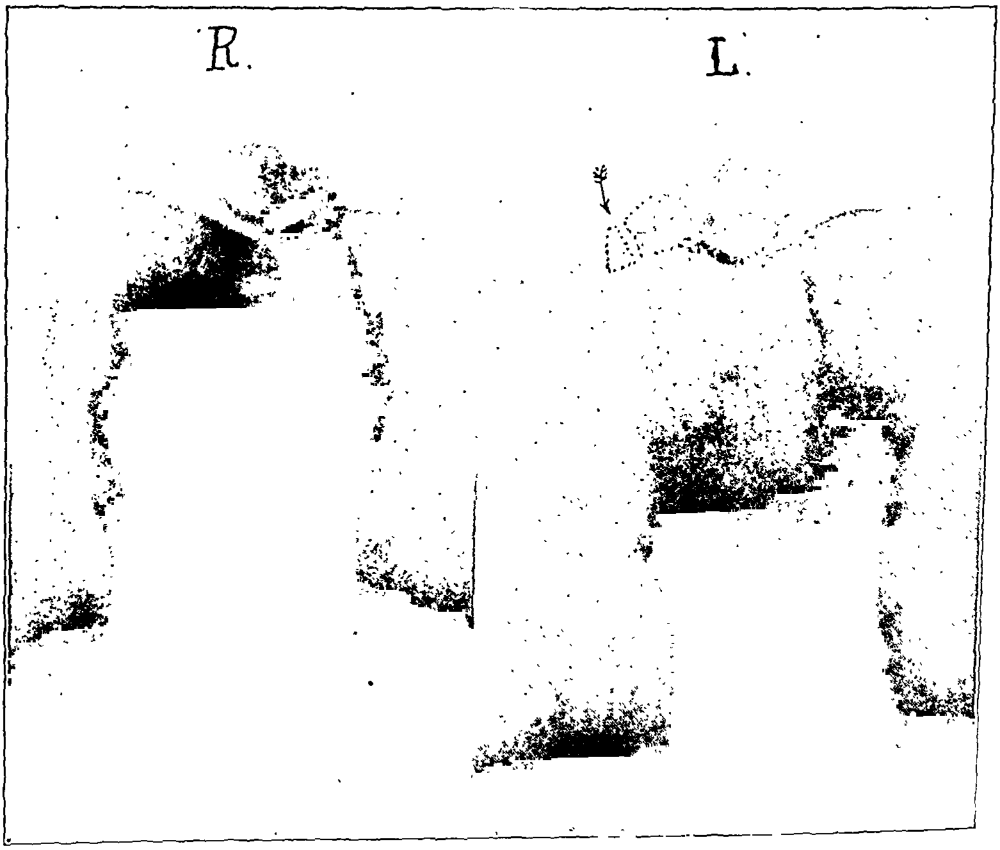

FIG. 8-A

Case 9. Accessory center of ossification over the outer border of both patellae. Note the free fragment (retouched) over the outer border of the left patella.

synovial cells. Wassermann and gonococcal complement fixation in the fluid negative. Culture negative after incubation for eleven days."

Conclusion: "The low icterus index excludes a direct traumatic effusion which could cause a tear in the capsule or an intra-articular fracture. The relatively small amount of cells and low percentage of polymorphonuclears show a chronic low-grade inflammation. The high percentage of synovial cells indicates hypertrophic changes in the membrane. Diagnosis: Chronic unspecific hypertrophic synovitis."

The guinea pig inoculated with the fluid from the right knee joint on February 27, 1931, was reported on May 8, 1931, as showing no evidence of tuberculosis.

March 17, 1931: Right knee was considerably improved. There was only a moderate tenderness over the lateral border of the patella and slight effusion still present. Flexion of the right leg was possible to forty-five degrees with pain at further flexion. There was present also some effusion in the left knee joint.

March 31, 1931: Patient still complained of pain and stiffness in the right knee joint. Four cubic centimeters of brownish, thick fluid was aspirated from the right knee joint. Strapping was applied. The patient, following this visit, became ill with influenza and nothing more was heard from her. When reexamined on August 4, 1931, patient's right knee was negative except for a slight tenderness along the line of the fracture.

This patient was the only one of those seen by the writer a few days after the injury, where the effusion was not of a hemorrhagic type.

As shown in the roentgenograms (Figs. 6-A and 6-B) there were marked proliferative osteo-arthritic changes over the patellae. The lateral border of the right patella, which broke off, could be considered as a newly formed

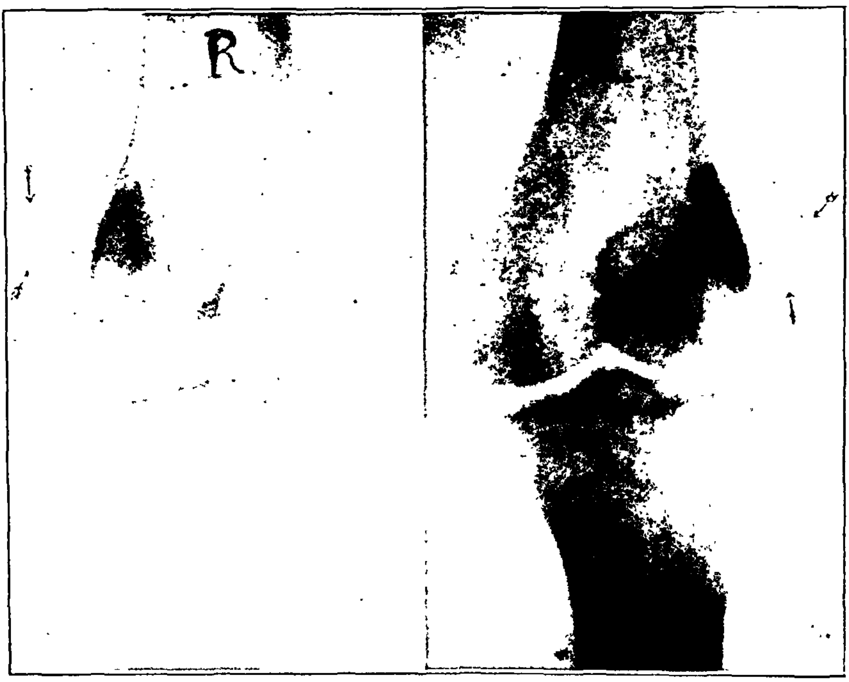

Fig. 8-B

Case 9. The accessory center of ossification seems to be free over the outer border of the left patella and fused with the main body of the right patella as pointed out by arrows. The original films showed this condition more clearly.

bone due to osteo-arthritic changes. The line of fracture ran laterally t the real body of the patella, which is covered with a cartilage over i posterior surface. Therefore, the space between the fragments did nc communicate with the joint,—the hemorrhage taking place into the sol tissues surrounding the patellar border without penetrating into the join

There is also a possibility that in this case we were dealing with a accessory center of ossification over the lateral border of both patellae, (Se Figure 6-B, left patella) the fracture of the right patella being only a trau matic separation of the accessory center of ossification at the place of it fusion with the main body of the patella, as pointed out by Zwerg.

CASE 8. Mr. F.K., a laborer, fifty-nine years old, was seen by the author at th Night Clinic (Dr. I. Tunick, Chief) at the Hospital for Joint Diseases on May 5, 1929.

The patient complained of pain and stiffness in his right knee joint following a injury a few years before his admission to the clinic. He was treated then as a compen sation case, the true nature of his condition being unsuspected. Upon examination, a considerable effusion was found in the right knee joint. On aspiration, yellow fluid wa obtained. There was no tenderness over the patella. The roentgenograms were inter preted as an old case of longitudinal fracture of the right patella with marked productive osteo-arthritic changes. This case is an illustration of the chronic synovial change which may take place in unrecognized longitudinal fracture of the patella (Figs. 7-A and 7-B).

CASE 9. Mrs. Y.H., a housewife, forty-one years of age, came to the Dispensary of the Hospital for Joint Diseases on Dr. S. Kleinberg's service, on March 26, 1930.

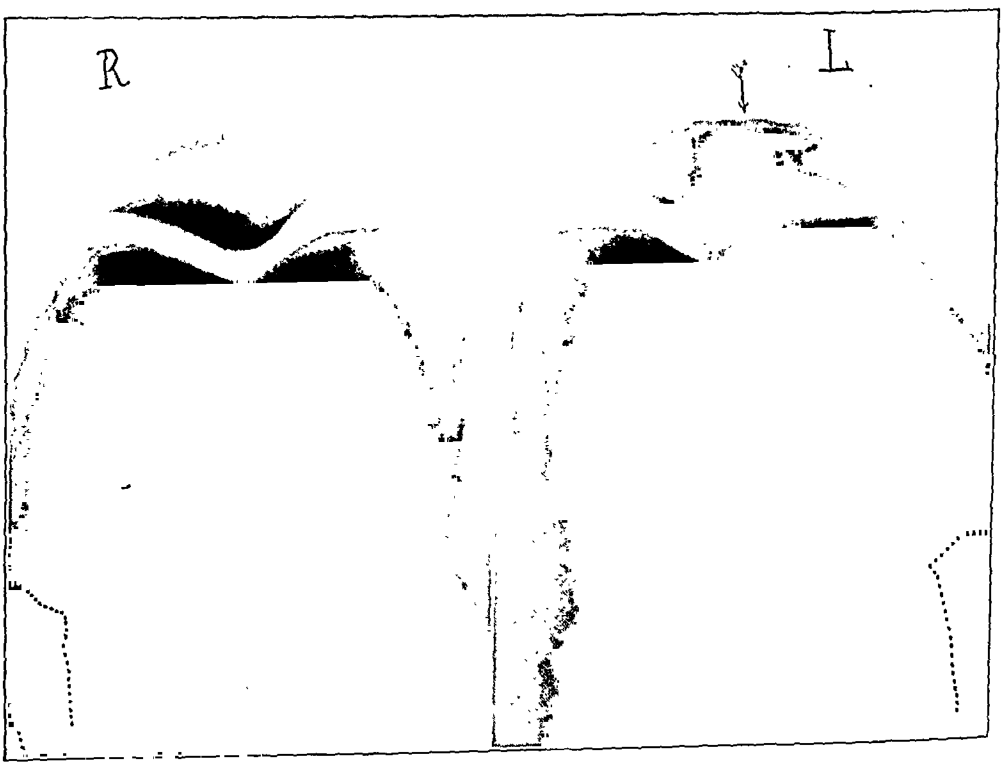

FIG. 9-A

Case 10. Oblique fracture of the left patella. Both patellae taken with the flexed-knee technique in the same exposure. This fracture cannot be clearly shown in this view. Slight gap may be seen on close examination of the film over the point of the arrow. (Fibulae retouched.)

For a few months before admission, the patient complained of pain in the left knee, her condition becoming gradually worse during the week before admission. In spite of thorough questioning, the patient denied any knowledge of injury to her left knee.

Examination revealed a slight swelling of the left knee without, however, any intra-articular effusion. There was no periarticular tenderness, nor was there any tenderness over the patella. The range of motion in the left knee joint was somewhat limited,—the angle of greatest extension being 170 degrees; of greatest flexion, seventy-five degrees.

The roentgenograms showed a small bony fragment in a vertical direction over the outer border of both patellae. The fragment was found free on the left side and fused with the main body of the right patella (Figs. 8-A and 8-B).

This case was interpreted as an accessory center of ossification of the patellae, because of no history of trauma, absence of localized tenderness, and symmetrical changes in both patellae.

The case in question may serve as an illustration of the great resemblance between the roentgenographic findings in longitudinal fracture and congenital malformation of the patella. The differentiation of these two conditions may sometimes present considerable difficulties.

CASE 10. Mr. J. O'B., a workman, fifty-nine years of age, was seen in the Out-Patient Department of the Hospital for Ruptured and Crippled on March 18, 1931.

On March 8, 1931, the patient fell on his knees with the leg flexed. He felt considerable pain in his left knee, but was able to walk home. He spent the next two days in bed.

FIG. 9-B

Case 10. Posterior anterior view of the same patella with slight external rotation clearly shows the fracture line running obliquely from up and in. (Fibula retouched.)

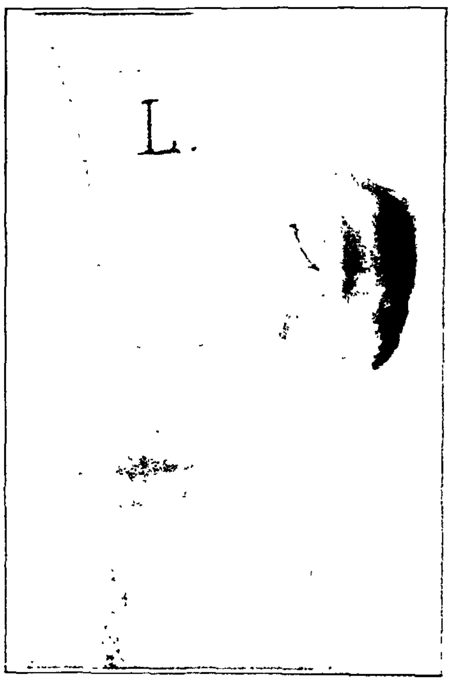

FIG. 9-C

Same patella seen in lateral view; illustrates that oblique fracture of the patella in contradistinction with the longitudinal one may be demonstrable in lateral view.

The patient walked with the aid of a cane. Upon examination, there was found effusion in the left knee joint. The right knee over the middle of the patella measured thirty-six centimeters, the left knee thirty-eight centimeters. There was a marked tenderness localized over the lateral third of the left patella. Other parts of the patella were not tender. No crepitation could be felt, nor was there any ecchymosis present. The range of motion of the left knee was normal,—the angle of greatest extension being 180 degrees, while the angle of greatest flexion was thirty degrees, with some pain on hyperflexion.

The diagnosis of longitudinal fracture over the lateral part of the patella was made. The roentgenograms, however, showed an oblique fracture of the patella (Figs. 9-A, 9-B, and 9-C). On aspiration only three and one-half cubic centimeters of bloody fluid with clots was obtained. Knee was immobilized for about two weeks in plaster-of-Paris casing which was followed by physical therapy. At the end of about six weeks, patient had made a complete recovery.

This case is an oblique fracture of the patella, but it is being included in this series because it presented all the typical clinical findings of a longitudinal fracture of the patella and was at first diagnosed as such.

Case 11. H. S., a schoolboy, thirteen years of age, was first seen at the Clinic of the Hospital for Ruptured and Crippled on April 1, 1929.

A month previous to his admission, he tried to kick a ball with his right foot, while the ball was on the ground. He missed and fell on his hands without striking his knees against the ground, twisting his right lower leg and bending it outwardly, the knee being

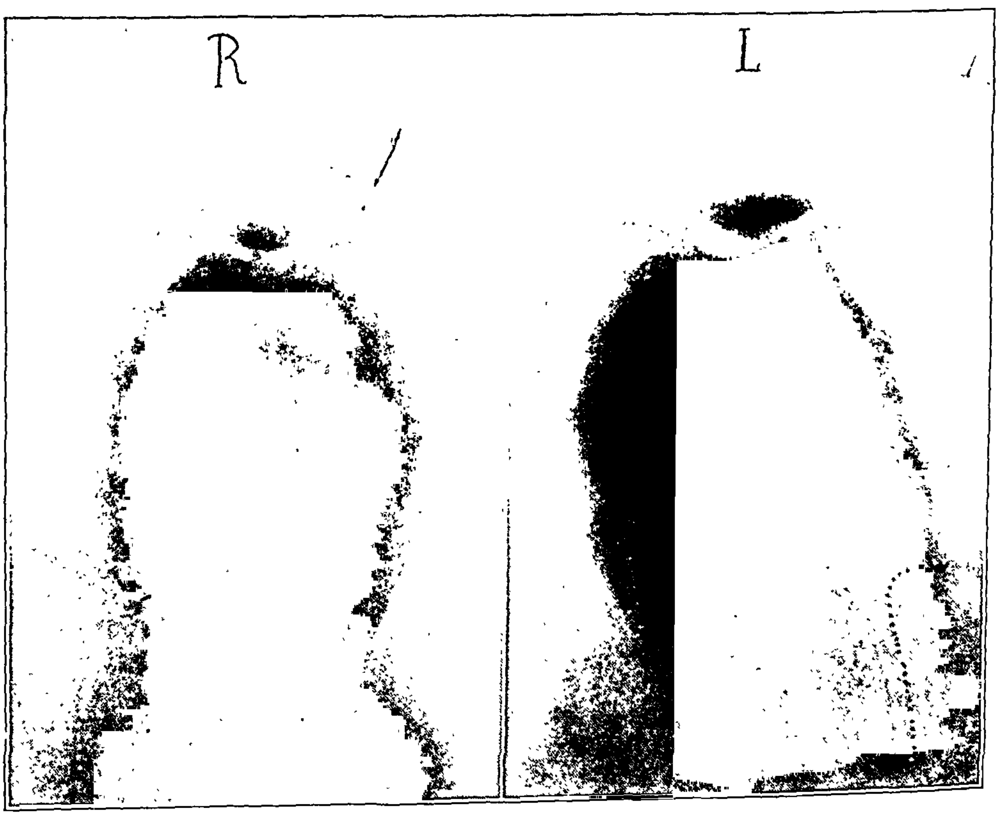

Fig. 10-A

Case 11. Longitudinal fracture over the medial border of the right patella; both patellae taken with flexed-knee technique. Note a small fragment over the medial aspect of the right patella (retouched).

in slight flexion. The patient immediately felt considerable pain and was unable to move his right knee which was locked in about 170 degrees, later becoming swollen.

On the following day, the family physician unlocked the knee by manipulating the patient's leg. The patient gradually recovered.

In the beginning of May, 1929, the patient again, while playing ball, sustained exactly a similar injury to the same knee, also twisting his lower leg in extreme abduction.

May 15, 1929: Examination by the writer revealed a moderate swelling of the right knee, right mid-patellar circumference being thirty-two and one-half centimeters, left thirty-one and one-half centimeters. There was a definite effusion in the right knee joint. The extension of the right leg was normal, but there was some limitation of flexion which caused pain at the knee joint. There was a marked tenderness, strictly localized over the medial border of the right patella, with no tenderness over the area of the medial semilunar cartilage, nor over the lateral medial ligament. Passive abduction of the right lower leg with the knee extended caused no pain. Roentgenograms of the right knee (Figs. 10-A, 10-B, and 10-C) showed an avulsion of the medial border of the patella corresponding exactly to the area of tenderness. The left knee and patella, in comparison, were found roentgenographically normal.

May 17, 1929: On aspiration of the right knee, seven cubic centimeters of dark blood was obtained. The knee was strapped with adhesive plaster. The patient was allowed to walk.

FIG. 10-B

Case 11. Posterior anterior view of the right knee taken with slight internal rotation to show the medial border of the patella. Note a small longitudinal fragment clearly demonstrable on the film (retouched).

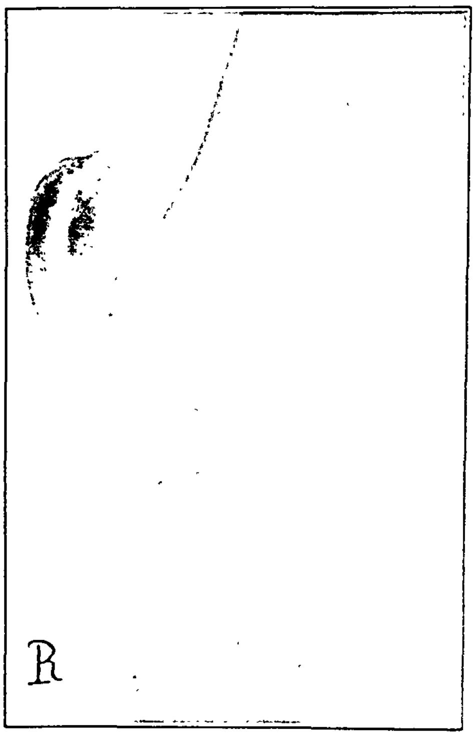

FIG. 10-C

The lateral view of the same patella shows no evidence of fracture.

May 31, 1929: Only slight tenderness was still present over the medial border of the right patella. There was no evidence of effusion in the right knee joint. Hyperflexion was slightly limited and painful. Physical therapy was given.

June 24, 1929: Patient was perfectly comfortable and was able to walk and run without pain. There was no effusion in the right knee joint and the tenderness over the medial patellar border had entirely disappeared.

September 27, 1930: The patient informed us that he had been quite comfortable except for occasional pain in the right knee joint on overexertion. The right knee was negative on examination.

April 1, 1931: During the past few months the patient experienced on two occasions locking of his right knee, once while swimming and once while playing ball. Examination revealed typical signs and symptoms of injury to the medial semilunar cartilage of the right knee, while the right patella was normal. The new roentgenograms showed complete bony union of the small fragment. The location of the former fracture could still be seen as a small projection over the medial border of the patella.

This case presents a combination of a longitudinal fracture of the medial border of the right patella with the derangement of the medial semilunar cartilage. It was our conclusion that the fracture of the patella occurred during the second accident in the beginning of May, 1929, while

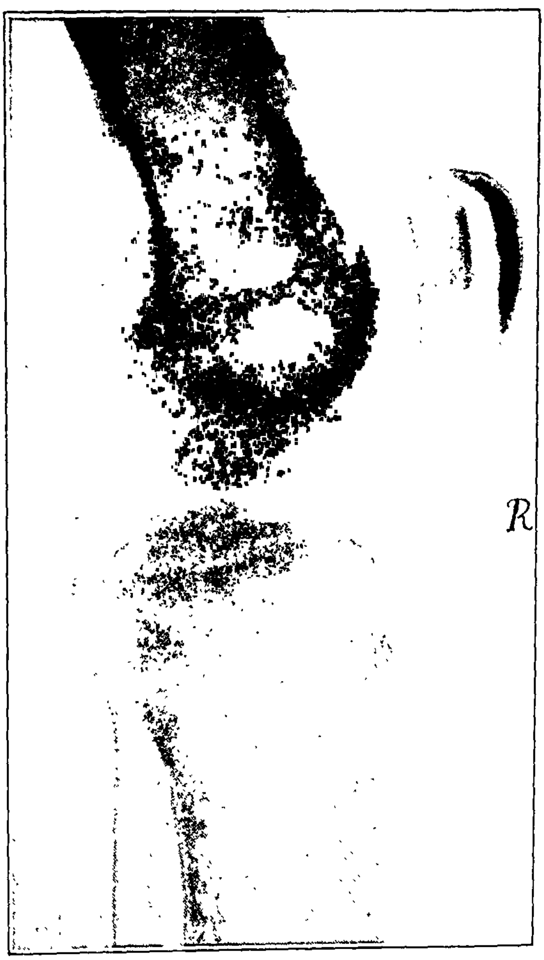

Fig. 11-A

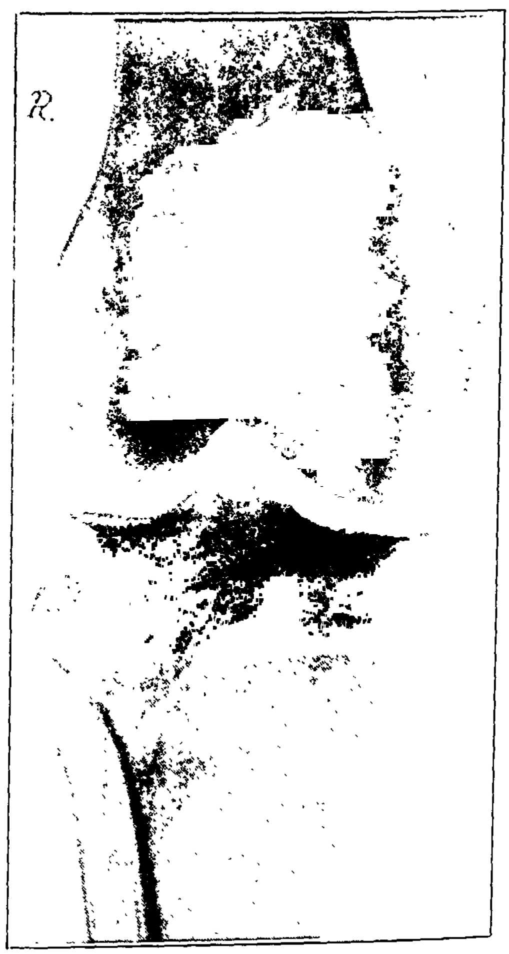

Fig. 11-B

Case 12. Routine lateral and posterior anterior views of the right knee showing no evidence of fracture.

all the other conditions of the knee were caused by the derangement of the medial semilunar cartilage.

CASE 12.* Mr. S.S., a porter, twenty-six years old, slipped and fell on a concrete floor, landing on his right knee with the leg in about ninety degrees' flexion. The accident occurred on December 21, 1931, at about four in the afternoon, and, in spite of a slight pain in the right knee, the patient continued to work for about one hour. At about ten in the evening the pain in the knee became so severe that the patient was admitted to the Hospital for Joint Diseases on the Service of Dr. Harry Finkelstein.

December 22, 1931: About 100 cubic centimeters of bloody fluid aspirated from the right knee joint. Routine roentgenograms of the right knee showed no evidence of fracture (Figs. 11-A and 11-B).

December 29, 1931: Twenty cubic centimeters of bloody fluid aspirated again from the right knee. Roentgenograms taken with special patella technique showed longitudinal fractures over the lateral and medial borders of the right patella (Figs. 11-C, 11-D, and 11-E). The left patella was roentgenographically negative.

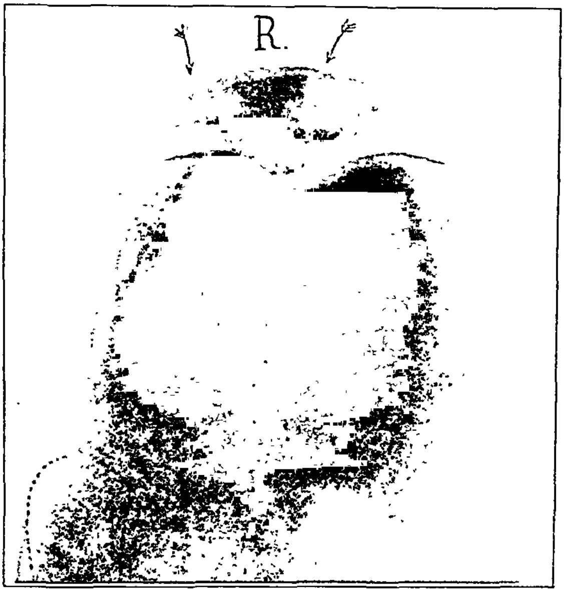

FIG. 11-C

Case 12. The roentgenogram of the same patella taken with the flexed-knee technique shows longitudinal fracture (arrows) over the medial and lateral parts of the patella (fibula retouched).

January 16, 1932: The patient was examined by the author through the courtesy of Dr. Harry Finkelstein. It was found that the patient walked without any limp and had no pain in his knee. There was slight tenderness still present only over the lateral border of the right patella, and a scant intra-articular effusion could still be observed in the injured knee. The range of motion was practically normal so far as it could be determined without removing the adhesive plaster strapping. The case is too recent to draw any conclusions in regard to its final results, but the author is quite confident that this patient will be able to resume his usual work five to six weeks after the accident.

MECHANICS OF THE FRACTURE

We note in almost all the cases described by different authors and also in the writer's series the exact location of the fracture line at the junction of the middle and outer quarters of the patella in a vertical and sagittal

*This case was added after the article had been sent out for publication. The author wishes to express his gratitude to Dr. Harry Finkelstein for his kind permission to include it in the above series.

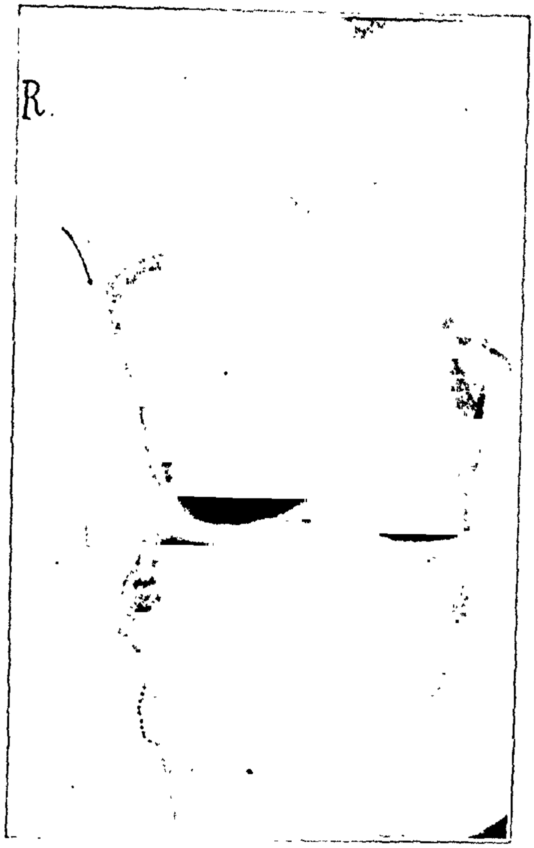

Fig. 11-D

Case 12. Posterior anterior view of the same knee with a slight external rotation. Longitudinal fracture (arrow) over the junction of the lateral and middle quarters of the patella is clearly demonstrable (fibula retouched).

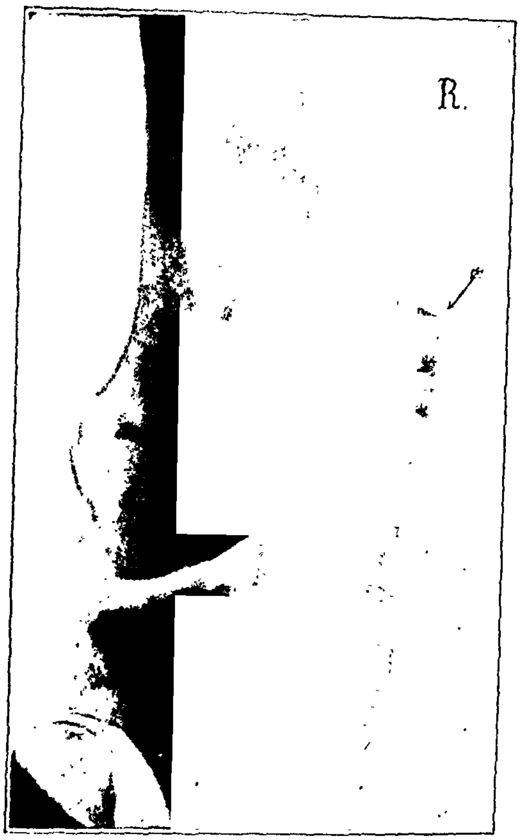

Fig. 11-E

Same view as on Fig. 11-D, but with a slight internal rotation of the knee showing a longitudinal fracture (arrow) over the junction of the medial and middle thirds of the patella.

direction. In three cases of the writer's series there was a longitudinal marginal avulsion over the medial border of the patella (definite in two and questionable in the third). It becomes quite evident from an analysis of the majority of cases described that precise, repeatedly-acting mechanical conditions must have been responsible for the production of longitudinal fracture of the patella,—conditions as precise as those observed in the Colles' or Pott's fracture.

The articular facets of the patella do not correspond to those of the anterior surface of the lower end of the femur, and the relation of the patella to the lower end of the femur is variable, depending upon the amount of flexion at the knee joint.

The outer border of the patella is subjected to a much stronger muscular pull than the inner, due to the attachment of the vastus lateralis, the strongest muscle of the thigh. This is reenforced by the action of the tensor fasciae latae and partly by the gluteus maximus which, pulling upon the tractus iliotibialis, tend to displace the patella outwardly, especially when the knee is bent.

Oetteking states: "during the action of flexion, the patella moves laterally . . . to assume an external position in front of the lateral condyle of the femur . . . the strain of flexion is withstood by the patellar ligament . . . it is this direct strain that in flexion somewhat sidetracks the patella laterally. The main agent here, as Kempson has shown, is the tendon of the vastus lateralis inserted into the upper portion of the lateral margin of the patella, in cooperation with the tractus iliotibialis and the retinaculum patellae laterale."

Were it not for the anteriorly projecting facet of the lateral condyle of the femur and the counteraction of the vastus medialis, the patella would be pulled outward by the action of these muscles. The normally present slight degree of genu valgum (which is one of the causes of more frequent occurrences of outward than inward dislocation of the patella) may also be considered as a predisposing factor in the tendency of the patella toward outward displacement.

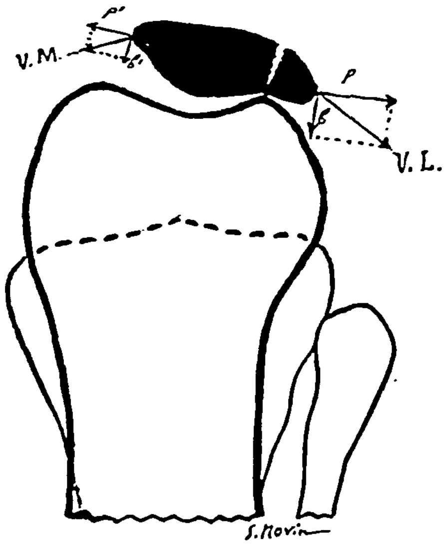

FIG. 12

Shows schematically the mechanics of a typical longitudinal fracture of the patella, occurring when the knee is flexed. Stronger action of the vastus lateralis is graphically represented by the force *V.L.* and has a tendency to displace the patella laterally. *V.M.* represents the force of the vastus medialis.

Each of the forces *V.L.* and *V.M.* may be decomposed, by building a parallelogram of forces, into two forces *pb* and *p'*,*b'* respectively. Forces *b* and *b'* tend to break the patella against the lateral condyle of the femur, the condyle serving as a fulcrum. Forces *p* and *p'* act upon the fragments in opposite directions, pulling them apart.

Roentgenologic study of the bony framework on horizontal sections of the patella at different levels brings Meyer to the conclusion that the lower outer part of the patella is the weakest part, because it consists of only spongy bone and has practically no cortical layer at all.

Todd and McCally, studying the patellae of twenty-three full-term foetuses found in forty patellae (out of forty-six) a portion of cartilage over the outer part which differed from the remainder in its color. Under the microscope this separate portion was found to be superficial. These authors therefore assumed that, although its presence is suggestive, it does not give any definite conclusions regarding the ossification of the patella from the cartilage.

The patella is freely movable passively in horizontal and vertical directions when the knee is extended. It may be displaced outwardly over the edge of the lateral condyle of the femur, so that the lateral one-quarter of its articular surface can be palpated outwardly beyond the anterior projection of the lateral condyle of the femur. This free mobility of the

patella is lost when the knee is flexed. Thus, on the one hand, the strongest muscle of the thigh is inserted into the lateral border of the patella, tending to produce partial outward subluxation of this bone, and, on the other hand, we have evidence of the weakness of the bony structure of the lateral part of the patella.

Both Meyer and later Tanton pointed out that, in lateral displacement, the patella rides over the anteriorly projecting edge of the lateral condyle of the femur. There is usually, in cases of longitudinal fracture of the patella, a history of a fall landing on the flexed knee, or a misstep with the patient losing his balance without a fall. In either of the cases a strong contraction of the extensors of the knee takes place in order to maintain the equilibrium of the body. When the knee is flexed, as described above, the outer quarter of the patella becomes subluxated outwardly, pivoting over the anterior projection of the lateral condyle. The action of the vastus lateralis and medialis tends to bend the patella, propped against the lateral condyle, in two parts and to pull the fragments apart as shown in Figure 12. This may create a typical longitudinal fracture of the patella over the junction of its middle and outer quarters, due to the bending and tearing effect (*Biegungrisseffect*, Meyer).

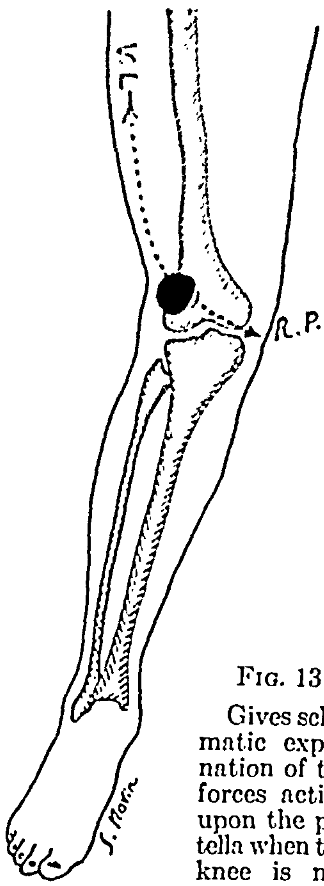

FIG. 13

Gives schematic explanation of the forces acting upon the patella when the knee is not flexed—as in Case 11. Note the increase of physiologic genu valgum, due to abduction of the leg caused by the violence.

V.L. represents the pull of the vastus lateralis, tending to displace the patella laterally and upwardly. The knee being extended, the upward motion of the patella is not prevented by the lateral condyle of the femur.

R.P. represents the retinaculum patellae mediale and the medial part of the joint capsule, which, being stretched, prevent further upward and outward displacement of the patella.

The ligamentous tissue being stronger than bone, a marginal avulsion of the medial border of the patella takes place. The oblique fracture in Case 10 may also be explained by the action of the same forces.

The marginal avulsion of the medial border of the patella observed in Case 11 may be explained as follows: The knee was only slightly bent, the patella therefore being more freely movable. A sudden abduction of the leg upon the thigh caused an increase in the normal genu valgum. The patella became displaced outwardly and pulled upwardly. This upward and outward pull, transmitted through the body of the patella, met a resistance over the retinaculum patellae mediale and the medial fibers of the capsule of the knee joint, which prevented further upward and outward displacement of the patella. A marginal infraction over the medial border took place, the force being stronger than the resistance of the patella (Fig. 13).

DIRECT OR INDIRECT INJURY

Direct injury to the patella has been considered the cause of longitudinal fracture of this bone in most cases. It was Meyer who believed muscular pull to be the significant feature in the production of this fracture. Hoffa's case of an acrobat who fractured his patella doing a somersault, without striking his knee against the ground, is the first case where a typical longitudinal fracture of the patella was produced by a definitely established indirect injury.

It seems to the writer that in the majority of these cases there must have been a combination of direct violence with the indirect action of the muscular pull. While in a few cases (like Hoffa's) a direct injury to the patella may be definitely eliminated, in other cases, classified as direct fractures, the action of the muscular pull upon the patella cannot be completely excluded. Campers stressed the fact that when falling upon the knee, landing on a flat surface, the patella does not strike the ground, being pulled upward by muscular contraction. This is worth considering when classifying longitudinal fractures of the patella as direct and indirect.

SIGNS AND SYMPTOMS

The clinical picture of longitudinal fracture of the patella is quite misleading. This is no doubt the reason why these fractures have been considered such a rarity, for a great majority of them must have gone into the records as "sprain of the knee", "synovitis of the knee", "internal derangement of the knee joint", etc., the true nature of the lesion being unsuspected. There is, of course, always a history of an injury to the knee, followed by a more or less marked disability. The disability, however, is never as severe as observed in the cases of transverse fracture of the patella, or fractures of other bony structures of the knee joint. The knee is usually stiff, but in most of the cases the patient is able to walk about. There is, as a rule, evidence of an intra-articular effusion (distension of the knee, patellar click) which is almost always of hemorrhagic type at the beginning, becoming serous later on. The presence of blood in the knee joint is easily understood, and is due to the fact that in most cases the line of the fracture penetrates through the thin cartilaginous covering of the posterior surface of the patella. Therefore, the space between the fragments of the patella freely communicates with the knee joint and allows blood to flow into it.

There is a limitation of passive and active flexion in the knee, while extension is only slightly impaired. A strictly localized linear tenderness in longitudinal direction over the lateral border of the patella is one of the most pathognomonic findings in longitudinal fracture of this bone. This tenderness can be elicited during the first four or five weeks following the injury.

It was this typical linear tenderness, noted in Case 1 and Case 7, together with other clinical findings, that made it possible for the writer

to be reasonably sure of his diagnosis before the roentgenograms were taken, and to request new roentgenograms with a special technique described below, after the routine pictures were reported in both cases as showing no evidence of fracture.

Other lesions of the knee—such as injury to the semilunar cartilages, crucial ligaments, etc.—may be associated with longitudinal fracture of the patella, and should be handled accordingly (Case 11).

ROENTGENOGRAPHIC TECHNIQUE

It is important to remember that the usual routine way of roentgenography of the knee (anterior posterior and lateral views) does not as a rule show a longitudinal fracture of the patella (Figs. 1-C, 2-C, 10-C, 11-A, and 11-B). On the anterior posterior view the shadow of the patella is superimposed upon the shadow of the condyles of the femur; while, on the lateral view, longitudinal fractures can never be seen.*

Laquerrière and Pierquin brought up the fact of the importance of a special roentgenographic technique for the study of certain details of the bony structures.

The roentgenographic technique employed by the writer in his series of longitudinal fractures of the patella consists of a posterior anterior, oblique view with the knee slightly rotated externally about fifteen degrees, while the patient lies on his abdomen with a film beneath the patella. The central ray is directed through the head of the fibula. This view gives a clear picture of the lateral part of the patella without superimposition over the shadow of the lower end of the femur (Figs. 1-A, 2-B, and others).

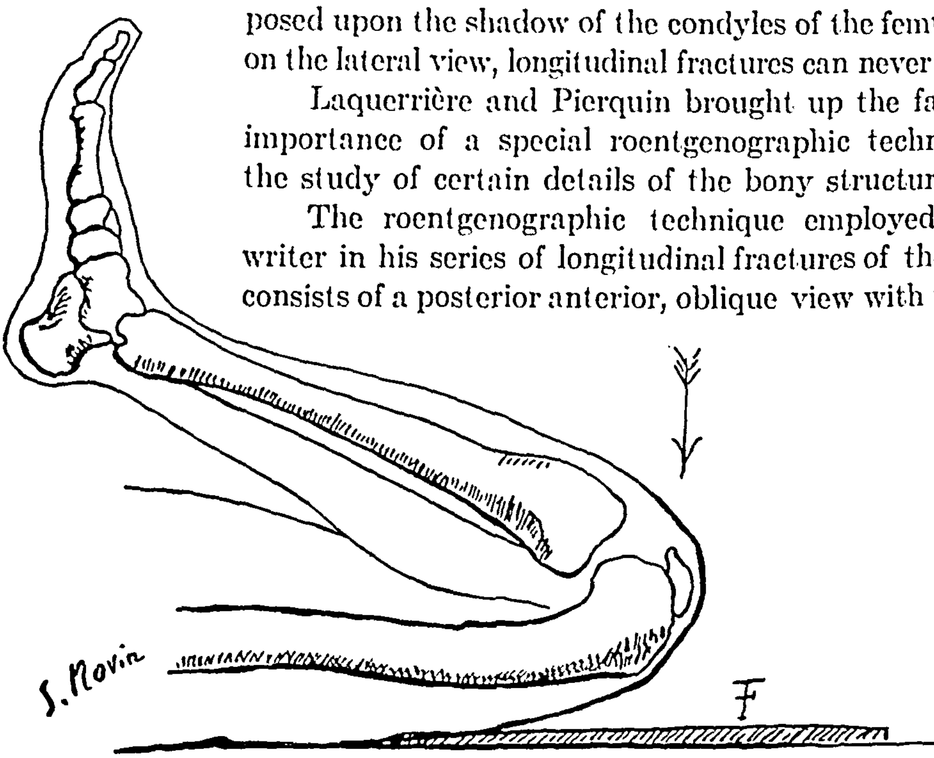

FIG. 14

Shows the roentgenographic technique employed in this series. Arrow points to the direction of the central ray of the tube. *F* indicates film. (Adapted from Fig. A, page 198, *Atlas Typischer Röntgenbilder vom Normalen Menschen*, by Rudolf Grashey. Munich, J. F. Lehmanns, 1923.)

*Except in very rare cases of longitudinal fracture of the patella, in "oyster shell", with plane of the fracture going in vertical frontal direction, dividing the patella in anterior and posterior fragments. Cases of this fracture reported by Kleinberg, Hirtz, Ginesty and Meriel, Stewart, Villar, and Leitloff.

In cases where the fracture is suspected of being over the medial part of the patella (as Case 11), pictures should be taken with internal rotation (Fig. 10-B). The other view is taken with the patient lying on his abdomen,—the film beneath the lower end of the femur, while the knee is flexed as sharply as possible. The tube is tilted so that the central ray passes parallel to the articular surface of the patella between it and the condyles of the femur, directed upward from the leg to the thigh (Fig. 14).

This view of the knee may also be taken with the patient kneeling on the film. The leg is flexed at the knee as much as possible without discomfort. The tube is tilted again, fixing the central ray the same as in the previously described technique, between the patella and the condyles of the femur, but in reversed direction,—from the thigh toward the leg.

Both patellae may be taken on one film in the same exposure, the central ray directed between closely approximated knees, while both legs are flexed at the same angle (Fig. 9-A).

With a little experience, both methods give a very satisfactory horizontal cross-section view of the patella, separately from the condyles of the femur as is evident from the illustrations.

In very recent longitudinal fractures with considerable effusion in the knee joint, it is sometimes difficult to obtain an acute flexion at the knee. In these cases it is advisable to aspirate the knee joint first, which has also a definite therapeutic value.

DIFFERENTIAL DIAGNOSIS

Congenital malformation of the patella may be easily mistaken for longitudinal fracture and should always be considered in differential diagnosis (Moreau, Fournier, and others). Sir Astley Cooper's case of bilateral longitudinal fracture of the patella, found in a cadaver, was probably nothing more than a congenital anomaly of this bone. In 1883 Gruber, meeting with a similar experience, also in the dissecting room, was the first to give a proper interpretation of his discovery as congenital malformation and named it "patella bipartita". Since that time there have been published a number of works devoted to the study of this anomaly. Odermatt in 410 roentgenograms found fifteen bipartite or multipartite patellae. Salmond observed fissures over the outer border of the patella, usually bilateral, but misinterpreted them as fractures. Todd and McCally, studying 682 skeletons, found a more or less marked defect over the upper outer border of the patella in three per cent. of their cases. This condition was noted on both sides twice as frequently as on one side. They concluded: "There is no doubt that the patella sometimes ossifies from separate centers in the vertical axis". The accessory centers of ossification are most often located over the outer upper part of the patella, which is also the most favored site of longitudinal fracture.

Zwerg brings out the point that the patella may ossify from two centers, the place of fusion being a locus minoris resistentiae. Trauma, causing separation of the fusion between the two centers of ossification, may give

the appearance of a patella bipartita. He is under the impression th some of the cases of patella bipartita, especially unilateral ones, are tl result of trauma.

The location, size, and shape of the fragments may be of some aid the differentiation of longitudinal fracture of the patella from congenit anomalies. In most fractures of the patella, the outer fragment is larg than in cases of malformation, and the line of the fracture usually rur over the junction of the middle and outer quarters in a vertical directio The accessory center of ossification in the majority of cases is smaller, a compared with the main part of the patella, and is usually located over th outer upper part of the patellar border, the condition being usually bilatera and symmetrical. In a few cases reported the accessory center of ossif cation was located over the medial border of the patella.

The history of an injury associated with the other findings, suggestin the traumatic nature of the lesion is, of course, important in differentia diagnosis. Injuries to the knee with a preexisting congenital malformatio of the patella may sometimes make the precise diagnosis quite difficult Mouchet observed a case of traumatic lesion of the knee in a boy fourtee years old, with a typical bilateral accessory center of ossification in bot patellae. His interpretation of this case as an apophysitis of the patell (*ostéite de croissance*), like Osgood-Schlatter's disease of the tibial tuberosity is quite interesting. Osteo-arthritic changes (Cases 7 and 8) may also present some difficulties in proper recognition of the fracture of the patella

It is important, especially in compensation and legal cases, to have as routine the roentgenograms of the healthy patella for comparison.

TREATMENT

Disability in longitudinal fracture of the patella is mainly due to the secondary involvement of the knee joint. In that respect longitudinal fracture of the patella resembles fracture of the skull, which practically requires no treatment as such, but all the therapeutic measures are directed toward the lesion of the brain. Similarly, in longitudinal fractures of the patella, the main aim of the treatment is to take care of changes occurring in the knee joint,—as hemarthrosis in the early stage and, sometimes, persisting synovitis in improperly treated cases.

Immediate aspiration of the knee joint with immobilization during the first three to five days by means of a posterior molded plaster-of-Paris splint, with elevated position of the limb, should be recommended in order to minimize the amount of posttraumatic reaction. After that, the patient may be allowed to walk with a strapping of his knee, avoiding the overuse of his lower extremity.

The writer believes that immediate aspiration of the knee joint and repeated reaspirations every two to three days, until there is no evidence of reaccumulation of the intra-articular effusion, is of greatest value in the treatment of this condition (Milch). This method of repeated aspiration

of the knee seems to shorten the period of disability. The patient in Case 1, treated in this way from the second day after the injury, was able to return to her previous occupation at the end of about five weeks. There may often be a persisting synovitis of the knee in cases improperly diagnosed, causing discomfort to the patient for several months and sometimes years, as in Cases 5 and 8.

So far as the fracture itself is concerned, the bony, or, in some cases, possibly fibrous, union of the fragments readily takes place as the fragments are approximated and kept together by the tonus of the quadriceps femoris.

It seems to be superfluous to make any statements against the use of open operations in treatment of longitudinal fractures of the patella as conservative methods insure complete recovery in approximately six to eight weeks.

SUMMARY

1. Attention is called to typical longitudinal fracture of the patella in a vertical sagittal plane, usually over the junction of the outer and middle quarters of the patella.
2. This fracture is not as uncommon as is usually believed, but is rarely recognized.
3. Correct diagnosis of longitudinal fracture of the patella is important for the purpose of proper treatment, especially in legal cases.
4. The clinical picture is clear cut: history of injury, localized linear tenderness over the lateral border of the patella, effusion in the knee joint (usually hemorrhagic), comparatively negligible disability.
5. Special technique of roentgenography of the patella should be used in every case with the above symptoms, where there is a suspicion of longitudinal fracture.
6. Both knees should always be roentgenographed in order to differentiate the fracture from congenital anomaly of the patella.
7. Therapeutic value of repeated aspiration of the effusion in the knee joint is emphasized in cases of longitudinal fracture of the patella.
8. Longitudinal fracture of the patella may lead to a quite prolonged disability when overlooked. If properly recognized and treated, complete recovery within six to eight weeks may be expected.
9. No operative treatment should be employed in these fractures.

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MAKING A NEW LIGAMENT IN ANKLE SPRAIN

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Chief: Prof. Patrik Haglund

Sprained ankle ("fork" sprain) is one of the commonest foot injuries and always leads to considerable and persistent complaints. It is a trauma due to an accident and one to which uncommonly little attention has been directed in the literature. Moreover, it is often missed or made light of by the attending doctor. When a patient seeks medical advice for a foot injury and the roentgenogram shows no evidence of fracture, the foot is often disregarded, the sprained ankle and the untreated ruptured ligaments being regarded as the cause of severe functional complaints.

Haglund has given a detailed description of the sprained ankle ("fork" sprain) in his treatise *Die Prinzipien der Orthopädie*[1] to which the reader is referred.

The reason for the publication of the following case report is that it offers an exceptionally striking picture of "fork" sprain. It is generally no easy matter to demonstrate these cases by documental evidence as the sprain is usually of so slight a degree as to require the most painstaking centering of the x-ray tube in order to obtain a picture of the sprain at all and the taking of control roentgenograms of the sound foot. Moreover, it is necessary to take pictures in different positions of pronation and supination to demonstrate the undue play in the astragaloid "fork". The present case which came to the author for operation was a good illustration of the condition and led to a new method of operation for stabilizing the sprained ankle joint.

The case is that of a girl, aged thirteen, who slipped when running upstairs; in so doing she got her foot forced in a direction of supination under her. She had a sensation of the external malleolus jumping out of its place and was unable to bear weight on her foot afterwards. She went to a hospital where no fracture was found under roentgen examination; fomentations were ordered. The foot continued to be unreliable and weak. On several occasions, even when walking on level ground, it had "jumped out of place". Each time that this had occurred the ankle had become swollen and had been useless for a few days.

Three and a half months after the accident the patient came to this hospital. There was nothing unusual to be seen on inspection,—slight tenderness over the external malleolus, some undue play in the ankle joint. Passively, extreme supination could be obtained. A roentgenogram of the ankle joint (Fig. 1) showed a somewhat wide "fork", also some slight irregularity of the tip of the fibula with a small separate bone shadow beneath (tearing of the ligamentous attachment ?). On passive supination (a weight of five kilograms), the astragalus was found to occupy a markedly transverse position in the widened "fork" (Fig. 2).

Operation was advised and performed by the author. By a curved incision behind and below the external malleolus, the superficial fascia was exposed. No evidence of trauma could be seen, but opening this layer, a large cavity was found just under the tip of the fibula, this cavity communicating with the ankle joint upward and with

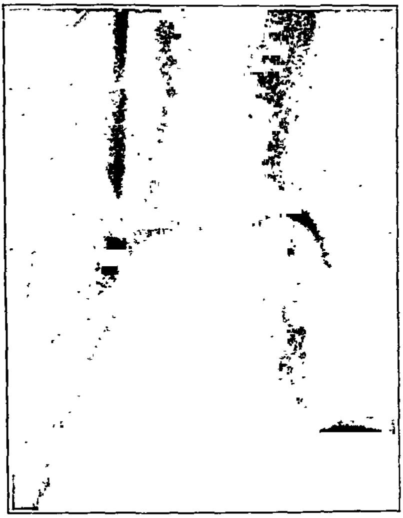

FIG. 1

FIG. 2

the peroneal sheath backward. The whole of this cavity was lined with synovial membrane which also seemed to have extended over the tip of the fibula, covering it. The calcaneofibular ligament was ruptured transversely, while the talofibular ligament was intact. The ankle joint was closed. The ruptured ligament was sutured as well as the peroneus brevis tendon, which was divided on the level of the retinaculum, in a groove subperiosteally on the outer aspect of the external malleolus. The central stump of the peroneus brevis was sutured to the peroneus longus; the foot was put in plaster. The plaster was removed after seven weeks and the patient began to walk in an orthopaedic boot. The ankle joint was found to be stable in a lateral direction; extension and flexion in the ankle joint were quite free.

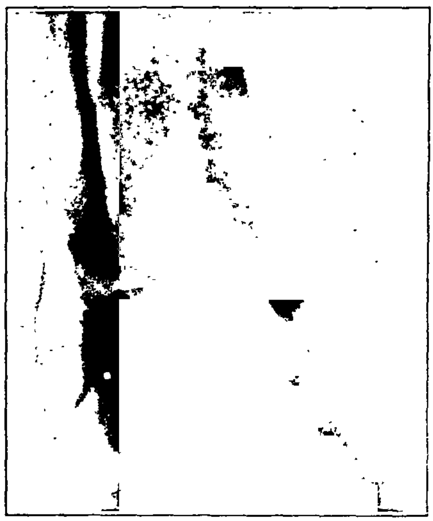

FIG. 3

Examination four months after the operation showed normal conditions. On roentgenological examination the astragalus was found to retain its position in the "fork" on forced passive supination (Fig. 3).

SUMMARY

A report is presented of a typical case of sprained ankle sustained by distortion in a position of supination, where rupture of the calcaneofibular ligament resulted in persistent laxity of the joint. The operative procedure consisted of suturing the ruptured ligament and fortifying it by the peroneus brevis tendon. A similar tendon-fixation operation has been suggested by Gallie for paralytic club-foot[2].

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A RARE ACCESSORY BONE OF THE FOOT

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No case of an accessory bone at the distal end of the os cuboideum is noted by Pfitzner[1], Dwight[2], Holland[3], or Shands[4]. I have recently observed such a bone which I believe has not previously been described.

Figure 1 shows in each foot an accessory bone three millimeters in diameter situated at the medial distal angle of the cuboid dorsally (stereoscopic examination). It is separated from the cuboid by a clear-cut line suggesting cartilage. It does not articulate with any bone except the cuboid. It appears to be pyramidal in shape, although on the left side its apex is rounded.

Figure 2 shows a minute process on the cuboid at the same point as the above described accessory bone. This process probably represents the same bone element as is represented by the accessory bone in the first case.

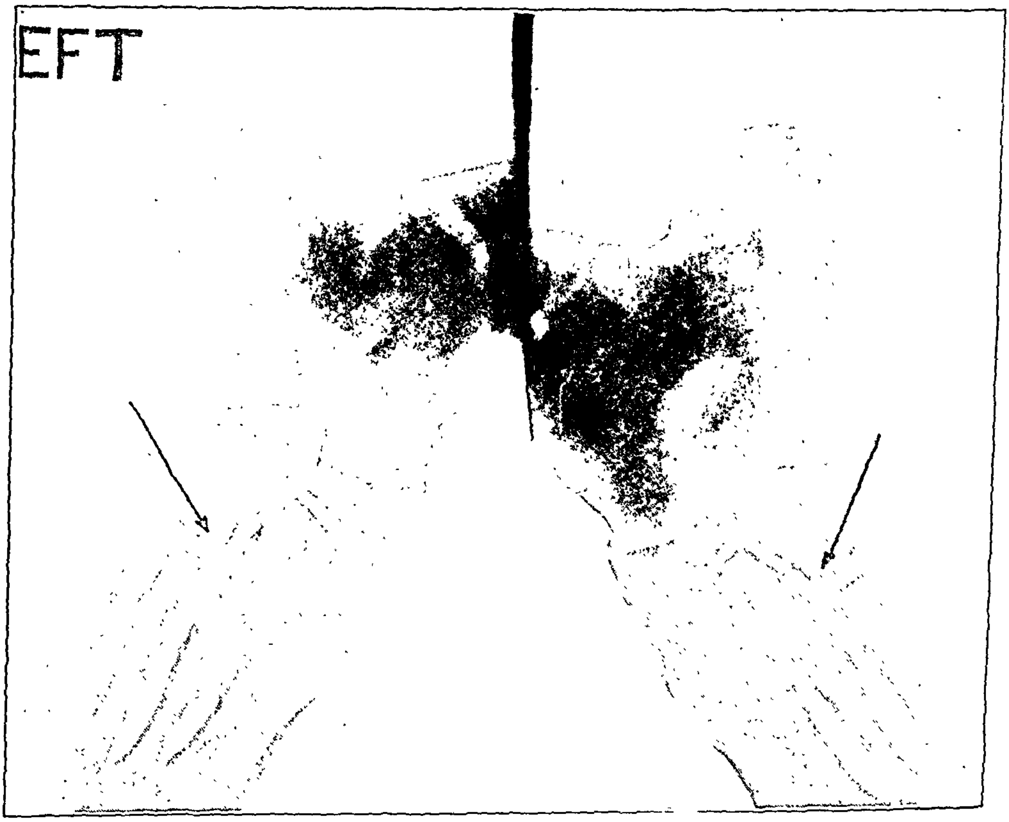

FIG. 1

Case 1. *Bilateral accessory bone at the dorsal distal angle of the cuboid medially.*

FIG. 2

Case 2. Bony process at the dorsal distal angle of the left cuboid medially. Right foot not examined.

Neither patient has symptoms referable to the area of the accessory bone element. The first patient was aged ten, male; the second was aged twenty-one, female.

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UNILATERAL SUBLUXATION OF THE LUMBOSACRAL JOINT*

BY SAMUEL KLEINBERG, M.D., NEW YORK

Unilateral dislocation of a vertebral articulation has been described in the cervical region, but I do not recall any mention in the literature of a similar lesion in the lumbar area. Recently there was sent to me by the New York State Labor Department a case of persistent back disability. The patient was seen by many physicians who agreed that the claimant was manifestly not malingering, but they could not arrive at a definite opinion as to the nature of the pathology.

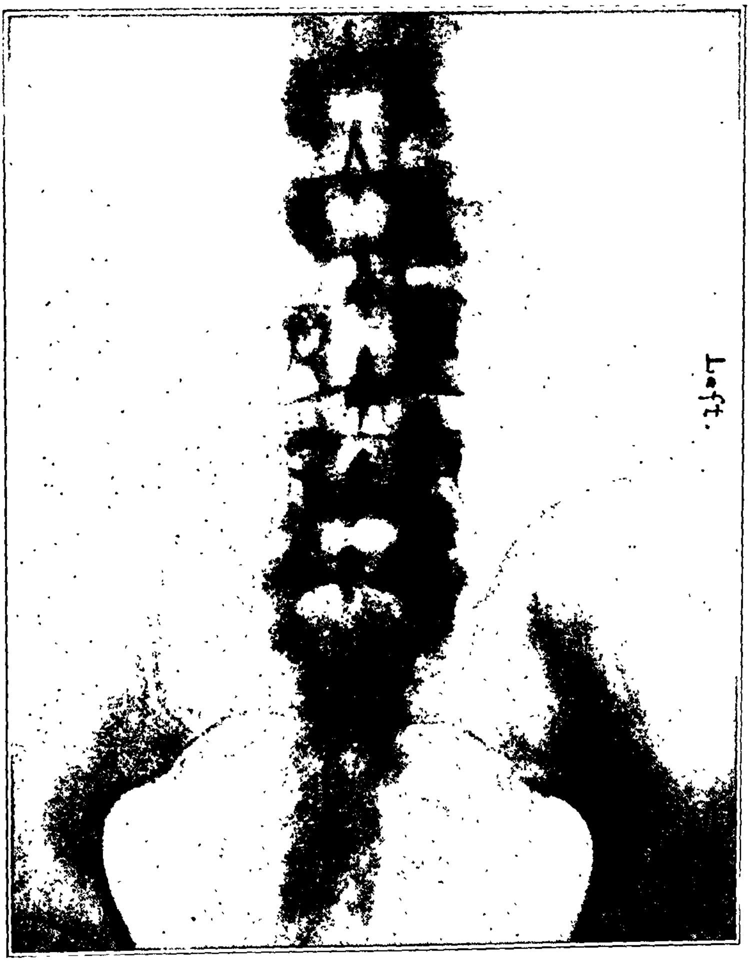

Fig. 1

Forward subluxation on right side of fifth lumbar vertebra. More evident in stereoscopic pictures.

The patient, a man thirty-eight years of age, was walking up a short flight of steps, about seven months ago, to dispose of a crate overhead when he lost his balance and wrenched his back severely. He immediately experienced pain in the lower part of his back. This has persisted and has disabled him. At present he can stand and walk without much discomfort, but a sudden movement of his body and any attempt to lift objects from the floor causes great pain. He can bend his trunk easily, but straightening from the stooped position is very painful. All his pain is referred to the right iliolumbar section of his back.

Examination shows a strong, muscular, very well built individual. He walks without assistance and

*Case presented at the Clinical Conference at the Hospital for Joint Diseases, December 1, 1931.

FIG. 2-A

FIG. 2-B

Stereoscopic films showing forward subluxation of the right lumbosacral joint as evidenced by the fact that the articular processes are one in front of the other instead of lateral to each other.

without a limp, but very slowly and guardedly. On first inspection his back appears symmetrical. After careful scrutiny, however, it becomes apparent that there is a mild asymmetry in the lower lumbar area; the left side is prominent and the right side flat or sunken. The spine is in the median line and there is no break in its anteroposterior physiological curve. Flexion of the spine is free and painless. The patient bends forward slowly, but he is able to reach the floor with his hands, when his knees are in extension. When he straightens he does so very slowly and complains of pain. Hyperextension of the spine is almost completely restricted and very painful. Similarly lateral bending in either direction is limited and painful. Forced hyperextension and lateral inclination of the trunk are intolerable. Palpation reveals a definite asymmetry of the lumbar region. On the right side the tissues are soft and yielding and the examining fingers sink forward at least an inch. On the left side there is a decided resistance. There is tenderness to pressure over the right lumbosacral articulation and over the right iliolumbar angle.

A flat x-ray picture (Fig. 1) shows a change in the relations between the fifth lumbar and the adjoining fourth lumbar and sacrum. Less of the fifth lumbar vertebra is seen on the right side than on the left. The right lumbosacral articulation is not visible, while the left is clearly outlined. From these observations one could hardly conclude what pathology, if any, was present, particularly as the anatomy of the fifth lumbar varies so much. However, stereoscopic pictures (Figs. 2-A and 2-B) reveal the lesion. In these pictures one can clearly distinguish that the fifth lumbar vertebra is rotated forward on the right side, and the articular processes are one in front of the other instead of lateral to each other as on the left side.

The clinical and x-ray appearances can, I believe, best be interpreted on the basis of a forward subluxation or dislocation of the right lumbosacral articulation. The fifth lumbar vertebra is rotated forward on the right side while the left side remains in approximately its normal position. The rotary dislocation of the fifth lumbar vertebra accounts for the flattening in the right lumbar area, the sensitiveness to pressure, the painful limitation of motion, and the disability.

A spinal fusion operation is manifestly the treatment of choice. This would result in ankylosis between the fifth lumbar and the adjacent vertebral segments. The patient would be relieved of pain. He could readily accommodate himself to the rather slight restriction of motion resulting from the fusion, and could undertake some useful occupation.

LATERAL DISLOCATION OF THE VERTEBRA

Report of Three Cases

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The frequency of observation of vertebral fractures has increased many fold through the use of radiography. This increase has been most marked in the past few years, due to improvements in equipment and technique which now allow a satisfactory demonstration of the spine at all levels and in all subjects.

However, even though the number of fractures discovered shows a marked increase, lateral dislocations are still rare in the literature and it is this infrequency which prompts the writer to add three cases to those already recorded.

Case 16035. N.D.W., female, aged fifty-seven.

Physical examination on November 29, 1927, on which date she was brought to the Woodland Clinic, revealed a woman of middle age, in general good health, and in quite

Fig. 1

Case 1. Anteroposterior view ten days after injury.

severe pain. There was partial paralysis of the left leg and almost complete paralysis of the right. There were areas of hyperaesthesia over the lower extremities and inguinal regions with diminution of reflexes and exaggeration of deep muscle sense.

X-ray examination disclosed lateral dislocation of the fourth lumbar vertebra on the fifth, the displacement being about two-thirds the width of the vertebra; fracture of the left lamina of the fifth lumbar; complete evulsion of all transverse processes; evulsion of the distal half of the twelfth rib, right.

On the following day a laminectomy was done and an attempt made to replace the vertebra with pulley traction and manipulation. This attempt was unsuccessful.

After a stormy convalescence the patient was able to leave the hospital two months later with no change in neurological findings. Two years after the accident the patient contracted lobar pneumonia and died after an illness of three days.

CASE 13583. H.E.P., male, aged thirty-five.

On May 20, 1930, patient was attacked by a bull and gored. After a short period of immobilization he returned to work and continued at work until September 1, 1930, at which time he reported to the Woodland Clinic for observation, complaining of pain in the back and kyphosis.

Physical examination revealed a definite kyphosis in the lower dorsal region associated with a rounded tumor in this area. Neurological findings were negative.

FIG. 2

Case 1. Lateral view ten days after injury.

FIG. 3

Case 1. One year after injury.

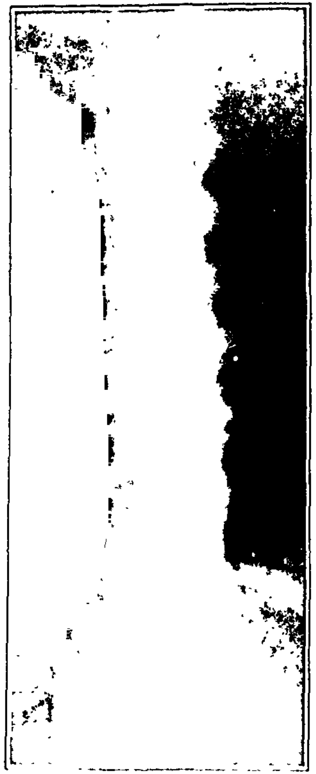

Fig. 4

Case 2. Anteroposterior view six months after injury.

Fig. 5

Case 2. Lateral view six months after injury.

Fig. 6

Case 3. Lateral dislocation of the fifth lumbar vertebra on the sacrum.

Roentgen examination showed crushing fracture of the twelfth dorsal vertebra with a large fragment knocked off the anterior surface of the body; marked narrowing of the eleventh intervertebral disc; lateral dislocation, three-fourths of an inch, of the twelfth vertebra on the eleventh.

No further observation has been made on this patient.

CASE 32481. W.R.S., male, aged forty-five.

Patient was riding in an automobile which was struck by a stage coach. He was brought immediately to the hospital.

Physical examination revealed bruises, contusions, and abrasions, subluxation of the right hip and right shoulder. There were no abnormal neurological findings.

Roentgen examination of the lumbosacral spine showed fracture of the first, second, third, fourth, and fifth transverse processes of the lumbar spine on the left; fracture of the fourth and fifth transverse processes on the right; transverse fracture of the sacrum extending from the lumbosacral joint laterally to the sacro-iliac joint on the left; fracture of the tip of the fifth lumbar spinous process; lateral dislocation of the fifth lumbar on the first sacral vertebra.

This patient is still undergoing treatment.

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DISLOCATION OF THE KNEE JOINT

With Report of a Case

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It must seem extraordinary that one of the most commonly used joints in the body, the knee joint, is so rarely subject to dislocation, though, in the light of our present-day knowledge, more often the seat of injury than any other joint. An exhaustive search of hospital records and the literature indicates that it is probably the rarest of the larger joints to be dislocated. As in other joints, such injuries may be complete and partial and are spoken of as luxation and subluxation. In discussing dislocation of the knee, we speak in terms of displacement of the leg—that is, anterior dislocation means forward displacement of the tibia. The tibia may be displaced in one of five directions—anteriorly, posteriorly, laterally, or medially, and rarely a rotary displacement. The stability of the knee joint is dependent upon the ligaments, muscles, and cartilage. Without tearing or stretching of these structures, dislocation cannot occur.

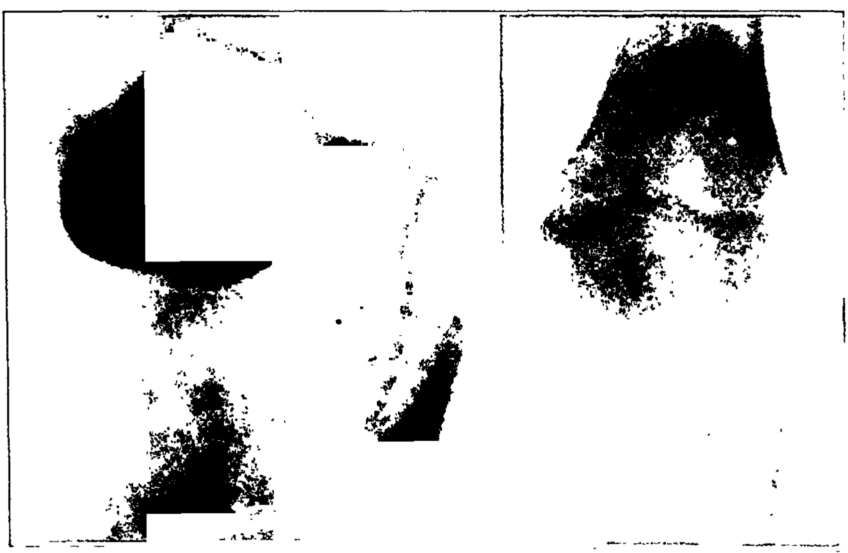

Fig. 1

Anterior dislocation of the knee without fracture.

In going over the records of more than 23,000 accident cases treated at the Reconstruction Hospital in New York City, only one case of dislocation of the knee was noted and that of the incomplete type. The New York Post-Graduate Hospital records reveal but three cases of dislocation of the knee, one of which was the result of a chronic infection of the joint and the other two of forward dislocations of traumatic origin. It is quite possible that a large number of dislocations of the knee joint are immediately reduced by some person pulling on the limb or by the patient.

Because of the apparent rarity of the condition, the following case is reported:—

Mrs. R.B., adult white female, sixty-nine years of age, married, mother of nine children, weighing 212 pounds, was five feet, two inches tall. On October 30, 1929, while walking on the street, the patient slipped so that her left leg lunged forward. She was carried to a hospital and about twelve hours later was seen by the writer. The diagnosis of forward dislocation of the left knee joint was obvious, though the possibility of an associated fracture was only ruled out by radiographic study. Her legs were of the fat, chunky type and it was rather difficult to find the bony landmarks. Under general anaesthesia, the knee was slightly flexed and manual traction made on the leg.

Fig. 2

Knee encased in plaster-of-Paris immediately following reduction.

FIG. 3

Knee joint thirteen months after injury showing partial ossification of joint capsule. No interference with joint function occurred.

The reduction was simple. The limb was then placed in a plaster-of-Paris case, extending from below the hip to the toes, for ten days. After removing the casing, she was given a walking caliper and with the aid of crutches was made to walk about. Gentle massage and guarded active motion were allowed daily. Ten weeks later the patient developed pneumonia and was confined to bed for three weeks. Then she was allowed up and about, and continued to wear the walking caliper for about five months because of instability of the joint. Thereafter, all restraining apparatus was discarded and she walked about with the aid of a cane. At that time she could extend her leg to a straight angle and flex it to an angle of 165 degrees. She continued active motion and the massage, and, at the expiration of eleven months from the time of her accident, she was able to flex her knee to a right angle and extend it to a straight angle. Thirteen months after her injury, she was steadier and surer of her footing and was able to walk without the aid of a cane and could climb stairs as well as she could prior to her accident. Motion of the joint was equal to that of the opposite limb.

In the three cases treated by Ransohoff[7] the end results were perfect and all the patients were active and working within a short time after treatment was instituted. He comments upon the fact that the end results were astonishing as contrasted with the postoperative results following derangements of the knee joint. In the case here reported, while the period of guarded motion was long, the period of healing time was short and weight-bearing was not allowed without support because of the obesity,

age, and general physical condition of the patient. From the literature and our own experience it is interesting to note that complete dislocation of the knee joint without fracture of the spinous processes of the tibia, although associated with intra-articular damage and severance of many small ligaments, heals readily. Yet cases of intra-articular damage, unassociated with dislocation, appear slow in healing and always have some residual after effects. This is the second case of anterior dislocation of the knee treated by the author. The first case was as follows:

A man, twenty-two years of age, when playing baseball, dislocated his knee while sliding to a base. It was easy to reduce the dislocation. No immobilizing dressings were applied. The knee joint was aspirated and about fifty cubic centimeters of bloody fluid removed. The patient was kept quiet for four weeks with daily massage to the joint. At the end of six weeks, the patient was walking about with but a slight limp and in eight weeks was back at work and discharged from treatment.

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RADIO-ULNAR SYNOSTOSIS

Historical Review and Case Report*

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Radio-ulnar synostosis is a relatively rare condition. It is found in both sexes, more or less equally. It is generally thought to be congenital and to occur bilaterally in fully one half of the cases. A strong familial tendency has been noted, also the influence of consanguineous marriage. The upper end of the radius and ulna is always involved, whereas the lower end is free. Supination is greatly impaired, the hand being held in a position of constant pronation. The condition is painless, is compatible with normal existence, and offers poor promise from surgical intervention.

Two types are known to occur. In the first—true radio-ulnar synostosis—the radius and ulna are smoothly fused at their proximal borders for a variable distance, usually two to six centimeters. In the second form there is a radio-ulnar synostosis with congenital dislocation of the head of the radius. There is also an acquired form which results from trauma such as fracture or gunshot wound (Jones and Hey Groves[1]).

Blaine[2] states that the condition occurs regularly in the bat and older deer.

Various theories as to its origin have been advanced—including the mendelian, ontogenetic, and phylogenetic views.

Radio-ulnar synostosis exists as a clinical peculiarity of great interest. The author, having encountered a case, found many discrepancies in the literature as to the actual number of occurrences of this condition. For historical purposes, he, therefore, decided to review all the known cases. In so doing, he has borrowed freely from the various authors.

HISTORICAL

Blaine[3], quoting Mouchet and Leleu[4], stated that radio-ulnar synostosis was apparently first discovered by Lenoir[5] at autopsy in 1817. However, the earliest record is actually that of Sandifort[6] who in 1793 reported three cases.

Smith[7], Verneuil[8], and Dubois[9], reported single cases in 1852. In 1856 Malgaigne[10] wrote of a case and was followed in 1863 by Voigt[11]. No cases were then heard of until 1880, when Allen[12] reported a case. This was followed by Pye-Smith[13] in 1883 with another.

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In 1892 Morrison[14] reported one case, and Abbott[15] contributed the largest series then known,—seven cases. All of these occurred in one family during four generations. This was the first authentic evidence of a familial tendency.

One year later, Cotterill[16] reported one case. Schmid[17] added two cases, and Cramer[18], one. Kümmel[19], in 1895, contributed three more, and Mickuliez[20], one. Hlawacek[21], with one case in 1896, and Münter[22], with three in 1899, brought the total number in the preceding 106 years to thirty-one cases.

After 1900, diagnosis was greatly aided by the use of roentgen rays. In 1900 Joachimsthal[23] added three cases and Stimson[24], another. In 1901 single cases were added by Longuet and Péraire[25], Appraillé[26], and Bardeen and Lewis[27]. Another was added by Lewis[28] in 1902, and one by Drenkhahn[29] in 1903. Blumenthal[30] contributed three more in 1904, and individual reports were given by Morestin[31], Schilling[32], and Helferich[33]. In 1905 Schmidt[34] reported one case, Roskoschny[35] two, Dun[36] one, Blodgett[37] two, and single cases were added by Stretton[38], Albertin[39], and Hamilton[40].

Stretton operated unsuccessfully upon one arm of his patient. The following year he operated upon the other arm successfully, using a sheet of sterile zinc between the separated bones in order to prevent fusion. He was unable to trace this patient subsequently.

Additional cases were noted in 1906 by Lunn[41], and Hoffa and Rauenbusch[42], and in 1907 by Redard[43], Palagi[44], Mummery[45], Rais[46], and Pollnow and Levy-Dorn[47]. In 1908 Goerlich[48] contributed two cases, and Grashey[49], Lett[50], and Pförringer[51], one each. A single case was reported in 1909 by Lieblein[52], whereas Ahreiner[53], and von Sury[54], added two and four cases, respectively. Thus in the ten years, 1900 to 1909, more cases were reported than in the preceding 102 years. The total was now seventy-one cases.

Again in 1910, single cases were added by Dietz[55], Preiser[56], Biesalski[57], Timmer[58], Riese[59], and Painter[60]. In this year Kienböck[61] contributed four cases and gave an excellent description of the condition, also compiling the best bibliography to date.

Grünfeld[62] had one case in 1911, and others were recorded in 1912 by Kreglinger[63], Blank[64], Dawson[65], and Melchior[66]. In 1912–13, Adams[67] reported one case, and in 1913 McGavin[68], Maass[69], and Mouchet[70], each reported one case, and Baisch[71] added four. At that time the latter believed that only thirty-eight cases, including his own, existed, although the actual count was now ninety-three.

Clarke[72] wrote of one case in 1913–14, and other cases were contributed by Madrange[73], Bossi[74], and Potel[75], in 1914. In this same year Martin-du Pan[76], added three cases and Wilkie[77], in a comprehensive review, added four more cases and discussed radio-ulnar synostosis from all known angles. This contribution ranks as one of the best, and it is the first exhaustive article to appear in English.

Hornung[78] published one case in 1915, and Schläpfer[79], another in 1916. Kurlander[80] listed one case in 1917; Ceresole[81] and Greig[82], two, Feidt[83],

an additional two, and Thomas[84], a single case. In 1918, Dubs[85] added two, Boorstein[86], one, Edwards[87], three, and Hohmann[88], one. Edwards then believed that his cases brought the entire total to forty-six cases, whereas the actual number was now 120.

Coudray[89], Kopelowitz[90], Aimes *et al*[91], Chesser[92], Sever[93], and Kaufman[94], each added a case in 1919. Evans[95], Sonntag[96], Kuh[97], and Jewesbury and Spence[98], each added a case in 1921; Beuchard[99] reported two more, whereas Rocher[100] and Aitken[101] each listed one. In Beuchard's cases the condition occurred in a brother, a son, and a son's son. He stated that up until 1921, in twenty of seventy-five cases treated surgically, there was only one successful result.

In 1922, Johansson[102], Sonntag[103], Michelsson[104], Wakeley[105], and Roth[106] each reported a case. In 1923, Gibson[107], Tristant[108], and Ombrédanne[109] each reported single cases.

In 1924, Davenport *et al*[110] reported the large series of fifteen cases and covered this condition most thoroughly. Davenport, as major essayist of this group, made a complete ontogenetic and phylogenetic study, and expounded all the known hypotheses of abnormal origin. He made the statement that in fifty-five per cent. of the parents in fifteen cases, one of the parents was synostotic. He came to the conclusion that radio-ulnar synostosis was partially sex-limited and that its occurrence depended on several variable factors. He believed that the fusion varied from two to six centimeters in length, and that the condition occurred twice as often in males as in females. He further believed that consanguineous marriage was a possible factor. His article is undoubtedly one of the best and is well worth reading. In this same year single cases were reported by Bennett[111], Gourdon[112], Giorgacopulo[113], and Marie[114], whereas Lüdin[115], reported three cases. An additional case was also noted by Jean[116].

Vogeler[117] listed a single case in 1925. In this year Greig[118], though not reporting a new case, wrote on, "Observations on the Bones in Congenital Radio-ulnar Synostosis". This article is a scholarly paper and contains the most accurate and authentic bibliography encountered by the writer. Mouchet and Leleu[119] also reported a single case. In 1926, cases were contributed by Bartsch[120], Crespellani[121], and Bertolucci[122], so that in 1926 a total of 170 cases had been recorded.

Additional cases were contributed in 1927 by Pepi[123], Schmidt[124], and Ciaccia[125]. The latter wrote a splendid treatise on the subject and compiled an excellent bibliography. Three more cases were added in 1928 by Voskresensky[126], and single cases by Siegmund[127], Roederer[128], Tamini[129], and Grossman[130]. In 1929 one case was noted by Boeckh[131], and the last known cases were contributed in 1930 by Davies[132], Hefter[133], Waegner[134], and Blaine[2,3]. The latter published two papers, each splendid in its content. Although no attempt was made to seriously review the literature and to tabulate the cases, Blaine[2,3] believed that they numbered between 100 and 200. The actual number, including the author's, which he now presents, and excluding any possible omissions, is a grand total of 185 cases since the first was reported, some 138 years ago.

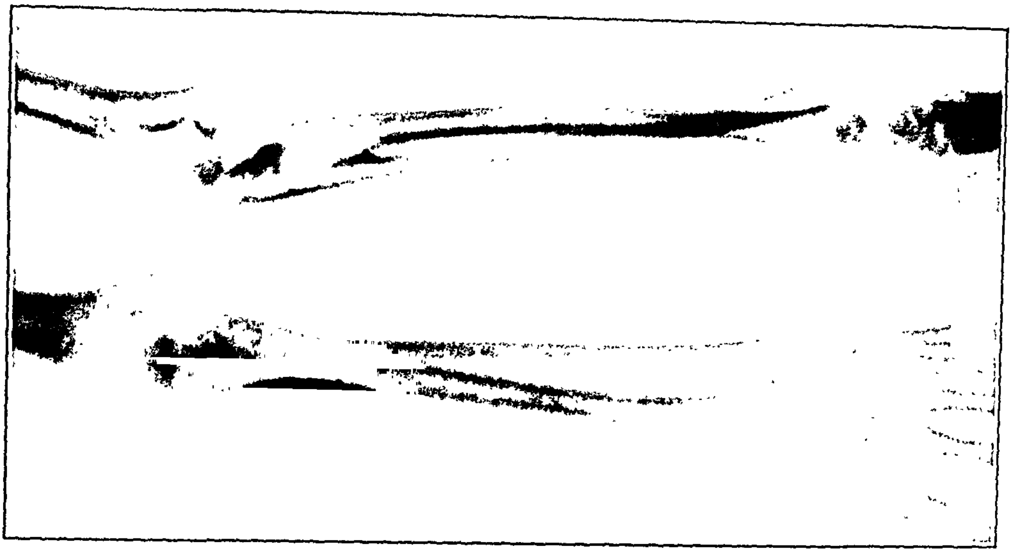

FIG. 1
Radio-ulnar synostosis, right forearm.

CASE REPORT

W.P., eight years old, male, white, was suffering from an acute exacerbation of rheumatic fever. Dr. Maurice O'Hern, the attending pediatrist, called the author in consultation because of the joint symptoms.

During the physical examination it was noted that the patient could not touch his right shoulder with the palmar surfaces of the fingers of that hand, nor could he supinate his right hand more than a few degrees. The radiocarpal joint seemed uninvolved, but attempts at forced supination met with resistance and caused a feeling of discomfort which the patient always localized over the head of the radius. The hand was constantly held in pronation, but all movements—such as grasping a pencil—were possible. The elbow was negative except for slightly limited extension. The left arm was perfectly normal. A preroentgen diagnosis of "probable radio-ulnar synostosis" was made. The x-ray report given by Dr. W. W. Furey, roentgenologist, read as follows: "The roentgenograms taken in the anteroposterior and lateral positions show a radio-ulnar synostosis (See Figure 1), involving the upper one and one-half inches of the bones. As a result of this synostosis, the distal end of the ulna seems to be displaced posteriorly. The bases of the metacarpal bones appear somewhat atrophic, possibly the result of disuse."

The patient is able to write with the right hand and otherwise seems to note no unusual dysfunction. He is normally right-handed. There are no other osseous deformities. The boy had bronchopneumonia at eight months, pertussis at one and one-half years, and rheumatic fever at two and one-half years. The abnormality of constant pronation and inability to supinate his right hand was entirely overlooked by his parents, and was first called to their attention one year ago by an observant school teacher.

This case appears to be of congenital origin. There is no history of familial occurrence. Surgical interference has been advised against.

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CONGENITAL BILATERAL RADIO-ULNAR SYNOSTOSIS

WITH REPORT OF CASE*

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Radio-ulnar synostosis, or "congenital pronation", is a rare developmental anomaly involving the bones of the forearm. It consists of bony fusion of the proximal ends of the radius and ulna which are otherwise normal. This abnormal union prevents normal rotation of the forearm. Radio-ulnar synostosis occurs more frequently in males, and is bilateral in about fifty per cent. of cases. Davenport, Nelson, and Taylor[1] have shown the existence of a definite hereditary tendency. Other bony defects may or may not be present.

The case reported here is of interest because the condition is bilateral and is of the "dislocated-head" type.

CASE REPORT

J.E., white male, aged thirty-eight, American by birth, was admitted to the hospital for the repair of an inguinal hernia. During the routine physical examination it was

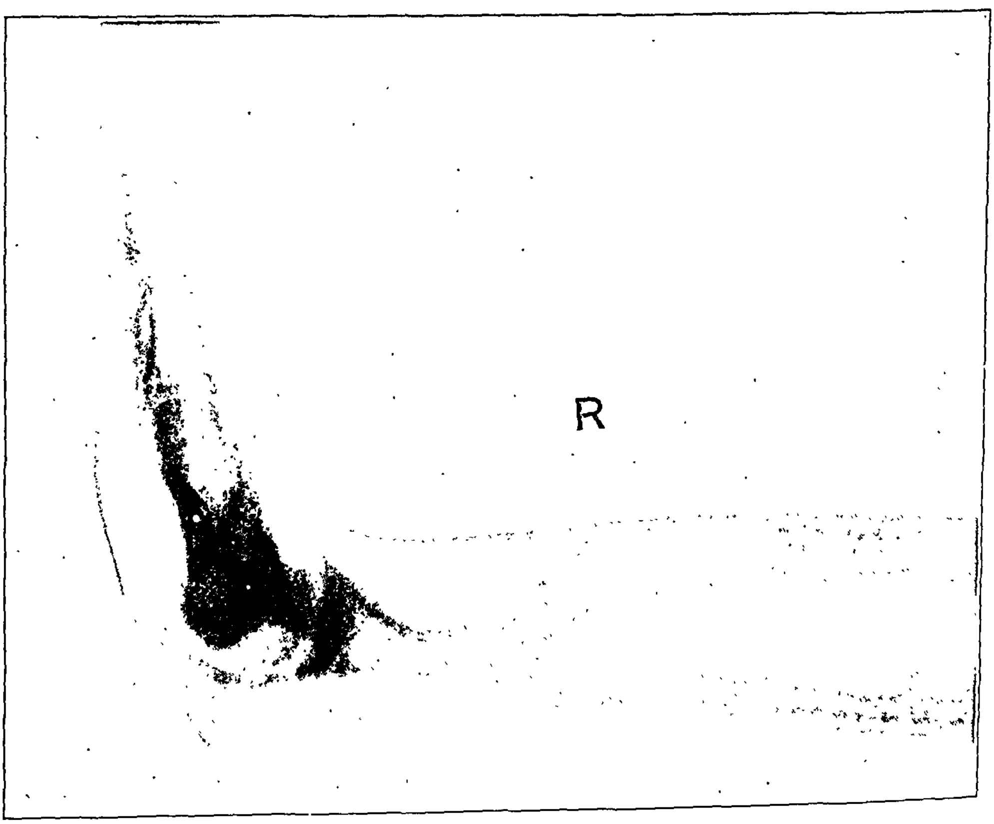

FIG. 1

Right elbow showing the abnormal bony fusion of the radio-ulnar joint and the anterior dislocation of the head of the radius.

*From the Surgical Service of Dr. G. L. Hays, Mercy Hospital, Pittsburgh, Pennsylvania.

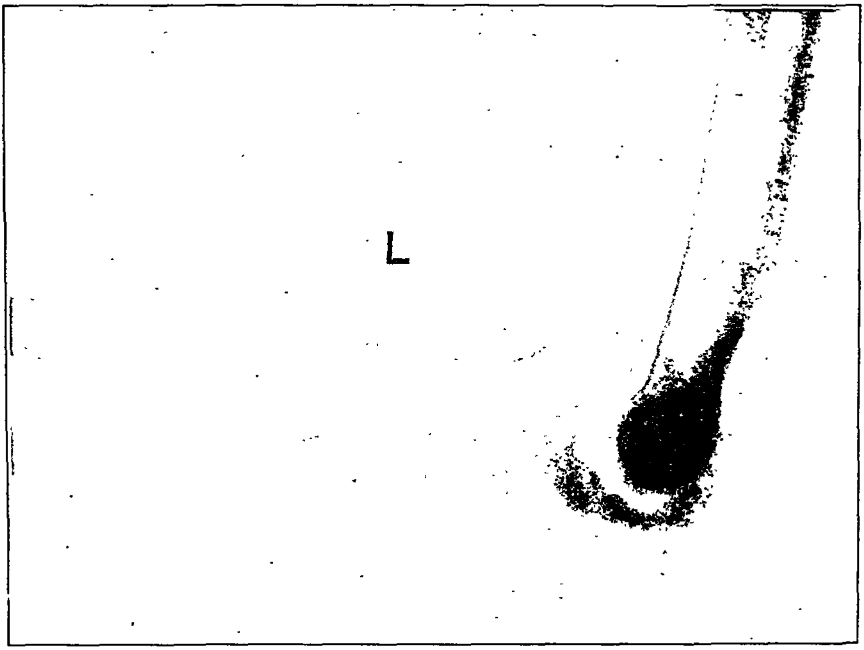

Fig. 2

Left elbow showing the abnormal bony fusion of the radio-ulnar joint and the anterior dislocation of the head of the radius.

noted that he was unable to supinate his forearms, which were fixed in a position of full pronation. Measurements of both arms and forearms were equal. Extension of both arms was normal, 180 degrees. Flexion of the forearms stopped at 121 degrees or about thirty degrees less than normal. All motions of the wrist joint were normal. The range of movement of the shoulder joints was greater than normal. The patient was able to extend his arms directly forward at a right angle from his body, then flex his forearms to a right angle, put the back of his wrists together, and touch his elbows against one another. No other skeletal or soft-tissue deformity was noted.

Roentgenographic examination of both elbows (Figs. 1 and 2) revealed a solid bony union between the proximal ends of the radius and ulna for a distance of five and one-half centimeters. The heads of the radii were present but displaced somewhat anteriorly, thus accounting for the limitation of flexion. The humerii were normal.

The patient's history showed that birth had been normal. Except for the gamut of childhood diseases he had never been sick. The inability to supinate his forearms was first noted by his parents when he was two years old. A detailed cross-examination disclosed that no other members of his family were similarly affected. The patient is married and the father of two children, both of whom are normal.

He had been a telegraph operator for many years but at present is employed as a brakeman. His deformity does not interfere with the proficient execution of his duties. The only awkwardness of movement which he experiences is in such minor ones as dealing cards or accepting coins. In the latter instance, whenever possible, he first puts his hand on a counter and then rotates his arm from the shoulder in order to obtain supination.

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GIANT-CELL TUMOR OF THE OS CALCIS

REPORT OF A CASE TREATED BY RESECTION AND TENDON TRANSPLANTATION

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Giant-cell tumors of the os calcis are seen very rarely. In a recent survey of the literature of the past fifty-one years, Moore[1] was able to collect only four cases. To these he added three cases found in a study, by Bloodgood and his associates, of 1740 bone tumors. The writers wish to record an additional case and also to mention some of the problems of reconstruction which entered into the surgical treatment of this condition.

C. H. H., a male Chinese, aged twenty years, was first seen on August 10, 1931. He complained of pain in the right heel. This pain had been insidious in onset and had increased gradually during the previous two years. There was no history of trauma. At the time of examination the patient was unable to bear weight upon the heel because of pain. The general physical examination and laboratory tests gave normal findings. Local examination revealed considerable atrophy of the muscles of the right leg and foot. The right heel was definitely enlarged and flattened. The os calcis was firm in consistency and the surface was somewhat nodular. The subastragaloid joint showed limitation of motion with palpable and audible crepitation when the foot was moved. Roentgenograms showed expansion of the os calcis in all directions, particularly laterally (Figs. 1 and 2). The cortex of the bone was apparently intact. The surface

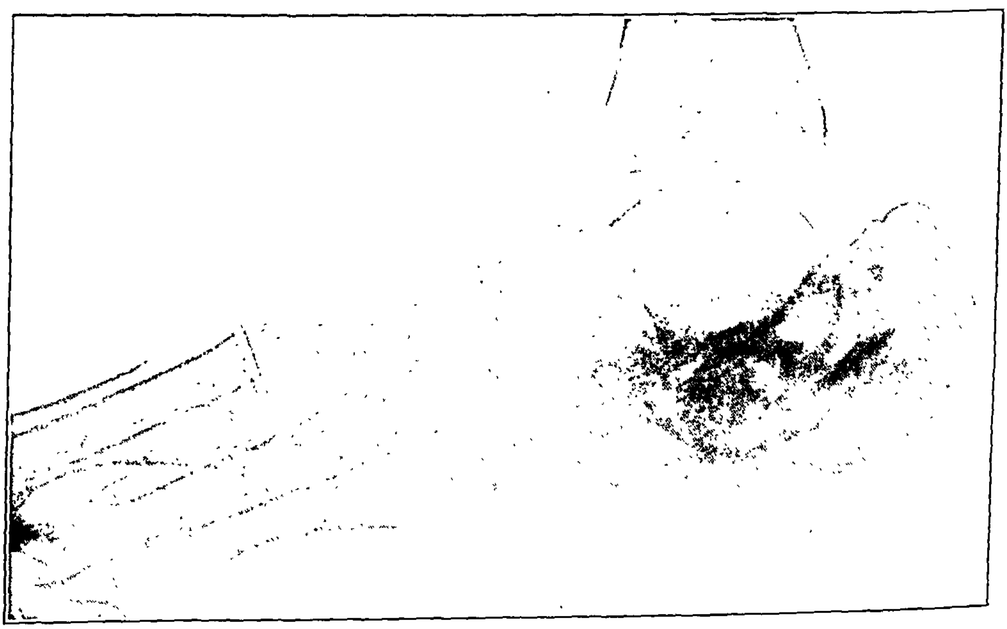

FIG. 1

Roentgenogram showing complete involvement of the os calcis by giant-cell tumor. Weight-bearing has caused compression of the mid-portion of the tumor.

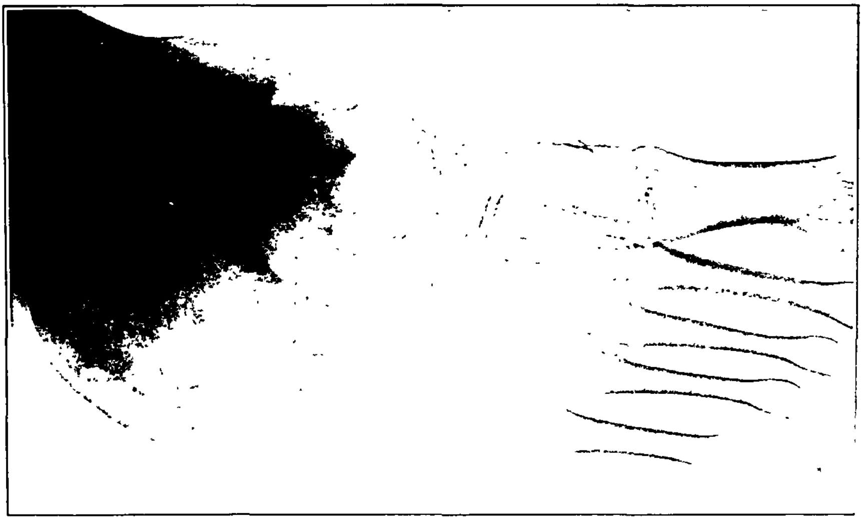

FIG. 2

Roentgenogram showing lateral expansion of the os calcis. The cortex of the bone is apparently intact in all portions.

articulating with the astragalus appeared irregular and slightly absorbed. Numerous cystic spaces with intervening areas of condensation were seen inside the expanded bone. The diagnosis of benign cystic tumor of the os calcis was made.

Treatment. Because of the extent of bony involvement, radiation and curettage were thought to be contraindicated. It was considered that, even though such treatment brought about complete destruction of the tumor, the patient would still be left with a rough and painful subastragaloid articulation. Amputation through the leg also was considered, because of the serious deformity and disability of the foot which usually follows complete removal of this bone. In the hope of overcoming the sequelae of complete resection, the following plan of procedure was adopted:

(1). The entire calcaneus was removed through a wide U-shaped incision (Fig. 3). (Frozen sections showed typical giant-cell tumor.)

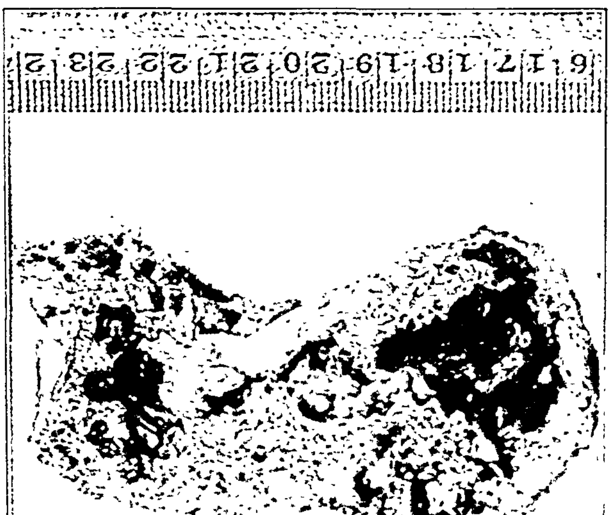

FIG. 3

A sagittal section of the resected specimen showing many cystic spaces. This illustrates the typical picture of giant-cell tumor,—an expanding cystic growth with marked destruction of bone.

(2). *The tendo achillis was lengthened and its lower end was fastened to the postero-inferior part of the astragalus through drill holes in this bone. It was hoped that by this means the calf muscles might still be of use even though placed at a great mechanical disadvantage.*

(3). The foot was held in forty-five degrees' plantar flexion during the tenodesis and, following closure of the wound, a long leg cast was applied with the ankle in the same position.

Microscopic Examination. Sections through the soft tissue showed a tumor consisting of spindle cells and many giant cells (Fig. 4). A few areas were hyalinized,

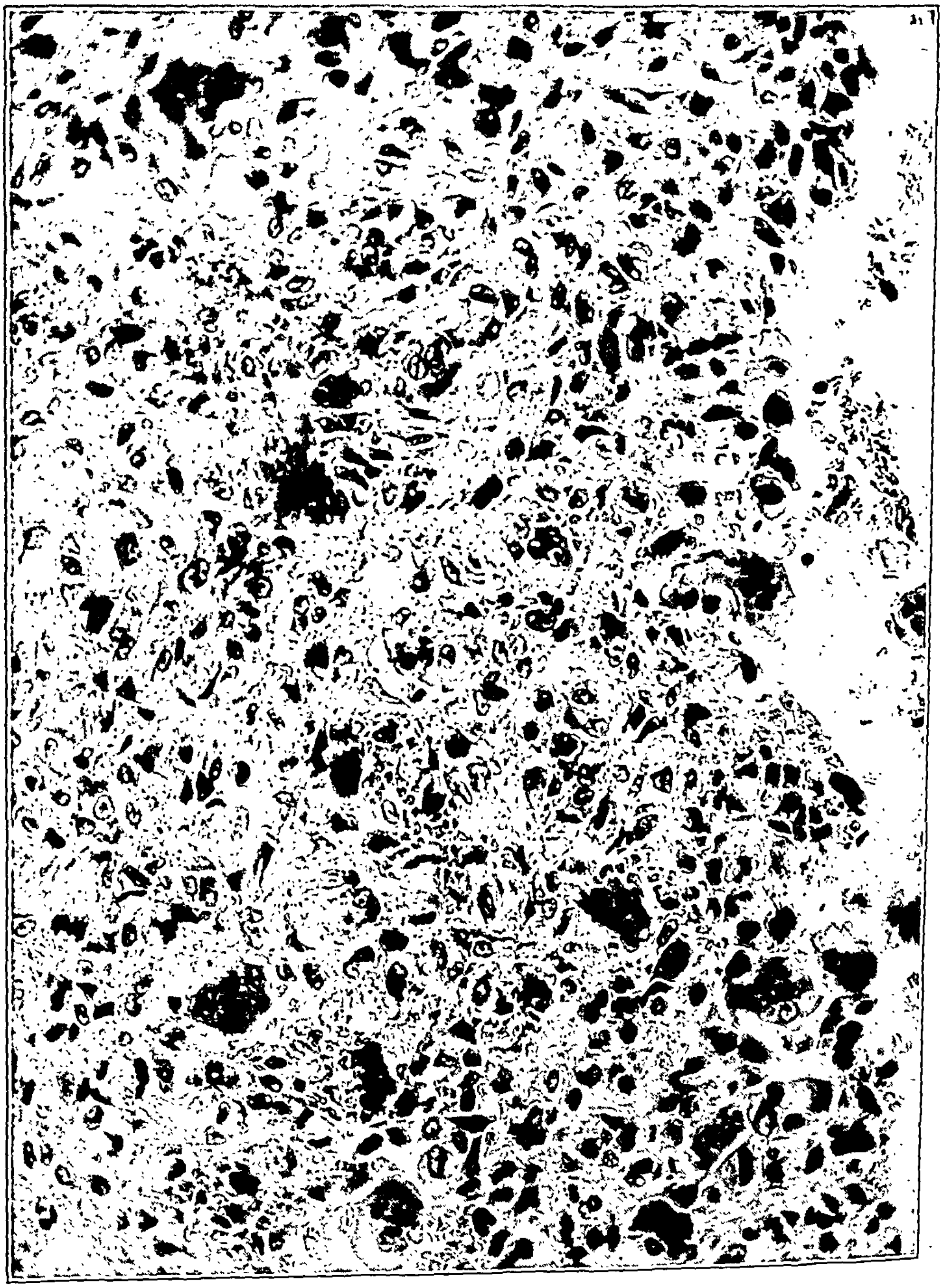

FIG. 4

Photomicrograph showing a characteristic section of tumor tissue. (×300) Numerous giant cells may be seen in a stroma of spindle cells.

while others were rather vascular. Mitosis was not observed. Sections through bone showed bone trabeculae with tumor tissue attached to them. Some cysts were present and contained blood. The walls of these cysts were formed mostly by tumor tissue. There were places showing osteoid tissue and newly formed bone trabeculae. Diagnosis: Giant-cell tumor with cyst formation.

Upon removing the cast two months later, it was noted that the Achilles tendon was strongly active in its new position. During the next month a removable splint in forty-five degrees' plantar flexion was used and the patient received daily treatments of baking and massage. At the end of this time a shoe was fitted with an inside elevation of the heel (three-fourths inch) and a light steel spring brace which supported the ankle in about fifteen degrees' plantar flexion. The spring gave an elastic resistance against dorsiflexion of the ankle (Fig. 5). Its action combined with the weak pull of the calf muscles prevented a severe calcaneal limp and the patient walked without pain.

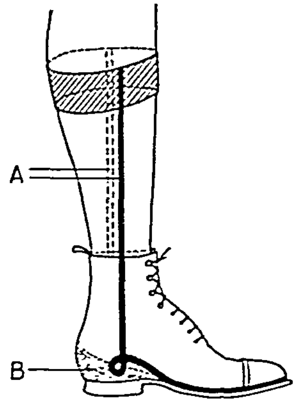

FIG. 5

Illustration of shoe fitted with a spring steel brace (*A*). Note the elevation (*B*) inside the shoe.

Concerning the prognosis for the function of this foot, it is believed that if a calcaneal deformity develops at a later date, correction may be accomplished by posterior transplantation of the peroneus longus and tibialis anticus tendons. In the event that this should fail, permanent stability could be obtained by arthrodesis of the ankle and mid-tarsal joints.

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GIANT-CELL TUMOR (SARCOMA?) OF THE ASTRAGALUS

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From the Orthopaedic Department of Jefferson Hospital

Giant-cell tumor of the astragalus is a rather rare and unusual condition. This is attested by a search of the literature which shows that in the past thirty-six years three cases have been reported; these were by White[1], Cazzamali[2], Michel[3]. Two additional cases are reported from the material in the Registry of Bone Sarcoma prior to 1925 by Simmons[4]. The case here reported presented some rather unusual features which, combined with the rarity of the disease, makes the case of more than ordinary interest.

W.K., white, male, thirty years of age, auto mechanic, was first seen at the Orthopaedic Dispensary of the Jefferson Hospital, April 2, 1931, complaining of a painful and disabling condition of the left ankle, which had been present since a fall from a mechanical conveyer, July 18, 1930. He was taken to a hospital where, after x-ray examination, he was told that he did not have a fracture and was treated for a "traumatic ankle" from the date of the accident until April 1, 1931. There had been no relief; instead the condition had gradually become worse under the treatment.

Upon admission he did not have any cast or dressing upon the part; he used two crutches, carrying the left foot off the ground. Discoloration, skin dimpling, and skin fixation were absent. There was a "bracelet" type of swelling more prominent on the medial aspect. The point of maximum tenderness was on the medial aspect of the os calcis just below the malleolus. There was motion of but a few degrees with no lateral motion in the astragalocalcaneal joint. The foot was held in a valgus position. Weight-bearing was impossible, due to the pain on the inner side of the os calcis and through the ankle. A clinical diagnosis of fracture of the os calcis was made.

X-ray examination showed a crush fracture of the posterior third of the astragalus, the astragalocalcaneal joint being obliterated in this area. Laboratory tests made upon admission to the hospital showed nothing unusual, although no test was made for Bence-Jones bodies then, or while the patient was in the hospital, as the tissue report was not received until after his discharge.

Operation, April 9, 1931. Astragalectomy by the lateral incision. When the astragalus was exposed the radiographic diagnosis was confirmed. When traction was made upon the head of the astragalus to dislocate it outward, the entire bone collapsed into a number of fragments. Extreme thinning of the shell of the bone was observed, the internal structure being replaced by soft hemorrhagic tissue, with lighter areas of apparent granulation tissue in it. Then, and only then, was tumor formation suspected. The fragments were carefully preserved and sent to the laboratory. Careful search was made in the surrounding tissues for pathology and none was found. The wound was closed without drainage, and the part placed in a plaster-of-Paris cast. Postoperative recovery was uneventful. The patient was discharged from the hospital in ten days. Five weeks later the cast was removed and he was referred to the x-ray department for treatment, which was given for a period of one month. He has reported for observation

monthly since that time. There is no evidence of recurrence either clinically or by roentgenogram. His general health has improved and he has been doing some light work at times, although he has considerable functional disability.

Laboratory Report by Dr. Baxter L. Crawford. Specimen consists of several pieces of irregularly shaped bony tissue; the largest piece, which represents the astragalus, measures five centimeters in its greatest dimension and is irregular in shape, the outer portion being composed of a mere shell of bone and the central portion being composed of a soft, red, hemorrhagic, friable tissue. The external surface is somewhat irregular and contains several articular surfaces. The bone is eroded in places. The other fragments are composed of bony tissue and soft, red, hemorrhagic, friable tissue.

Histology. Examination of the sections of the soft central portion of the tissue reveals that it is composed of cellular connective tissue in which there are innumerable giant cells and a fairly small amount of cellular stroma with numerous small blood vessels. The multinucleated cells vary greatly as to size and the number of nuclei present. In other small areas the vessels are larger and there is more connective tissue present, with fewer giant cells, and the cells are more of the spindle type, with larger irregularly shaped nuclei, many of which are undergoing mitosis. Sections of the periphery, including the bony shell, reveal a very small amount of bony tissue and cartilage present. There is evident bone destruction, but no evidence of bone formation is observed in any part of the tumor.

For the most part, the histological structure of the lesion in the bone is that of a typical, benign, giant-cell tumor, but in small areas there is more connective tissue present and fewer giant cells and many mitotic figures. It has many characteristics of a malignant lesion and for this reason it should not be considered as entirely benign.

Diagnosis. Giant-cell tumor of the astragalus, probably undergoing malignant change.

SUMMARY

A report is presented of a case of traumatism of the left foot and ankle, resulting in what was apparently a crush fracture of the astragalus but which proved at operation to be a giant-cell tumor, possibly undergoing malignant change.

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A CASE OF MULTIPLE SPONTANEOUS FRACTURES OF UNKNOWN ORIGIN*

BY EMANUEL B. KAPLAN, M.D., NEW YORK, N. Y.

Hospital for Joint Diseases

Multiple spontaneous fractures are observed not infrequently in children; they are also seen in adults, although less often. This case presents certain peculiarities.

The patient, a white female, about thirty-five years old, born in Norway, was admitted to the Hospital for Joint Diseases, in September 1930, with complaints of weakness in the extremities and fractures of the fingers of the hands. The fractures occurred in the course of her usual work of manicuring. Two and a half years previous to admission, while turning over a mattress, she sustained a fracture of the distal third of the right ulna. She was treated at the dispensary of the hospital. Four months later she returned with a fracture of the distal third of her left ulna. The roentgenogram revealed excess callus on the right side and recent transverse fracture of the left ulna. Her blood showed an eosinophilia of seventeen per cent.; the blood and spinal fluid Wassermann examinations were negative. She was under observation for a short time and showed on repeated examinations an eosinophilia varying between eight and thirteen per cent.

The patient seemed to be well for a short period of time until about six months before her admission to the hospital. Within these six months she fractured on different occasions the second and third metacarpals of the right hand and the proximal phalanx of the left hand. She did not suffer much pain, although she was much distressed by the inability to use her hands.

The family history was normal; no hereditary fractures were known. The patient had been married sixteen years. In 1915 she delivered a dead baby at seven months and was never pregnant again. In 1921 she had a cholecystectomy, appendectomy, and salpingectomy.

Nine years before, while in the West Indies, she was stricken with some tropical fever which lasted six weeks with severe daily chills and temperature reaching at times 105 degrees. A local physician diagnosed it as dengue fever, but she received no treatment. Since then she has suffered a general fatigue and occasional chills and fever, frequent vomiting, and occasional pain in the right upper quadrant.

The patient was thin, rather emaciated, showing a peculiarly mottled skin and a marked exophthalmos; the lungs and heart were normal; there was no palpable intra-abdominal pathology; no neuromuscular changes were noticed. The right hand showed an angular palmar deformity of the second and third metacarpals due to malunited fractures; the left hand presented a united fracture of the proximal phalanx of the second finger. The right and left feet showed a plantar angular deformity involving the shafts of all the metatarsals.

*The patient was studied on the Orthopaedic Service of Dr. Harry Finkelstein and presented before the Clinical Society of the Hospital for Joint Diseases on October 7, 1930.

Fig. 2

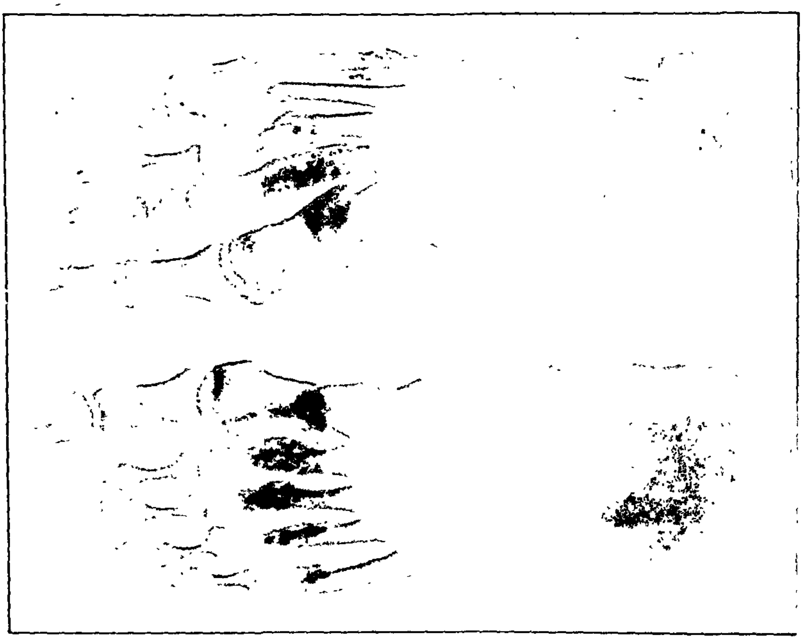

Fig. 1

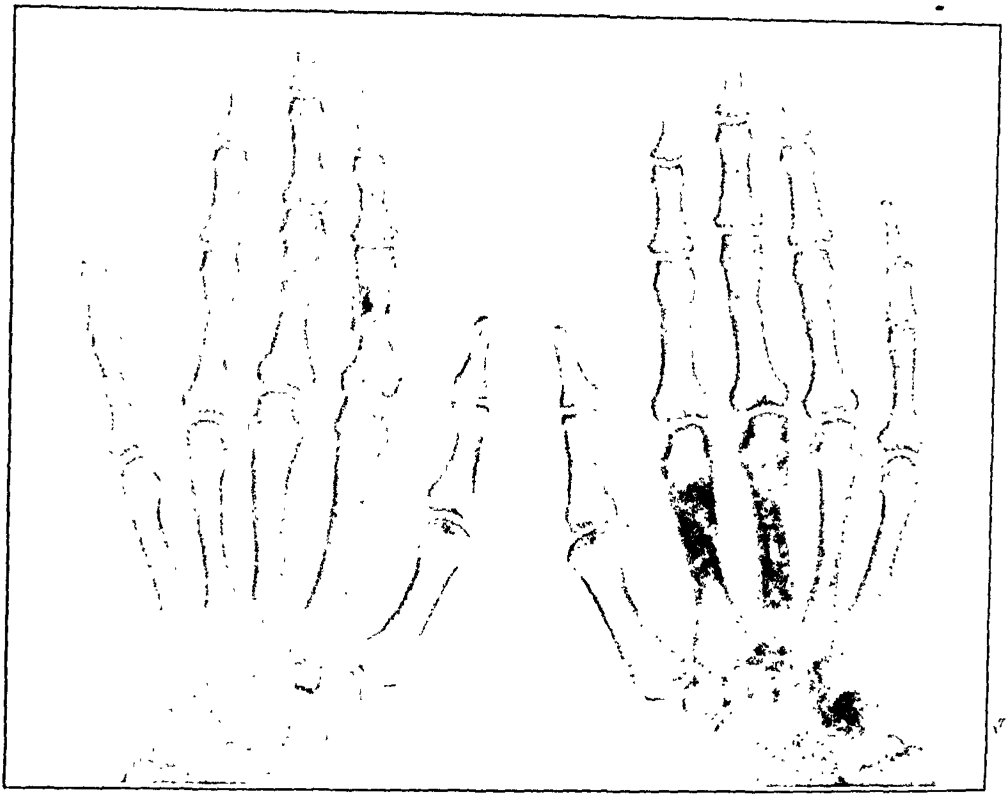

Fig 3

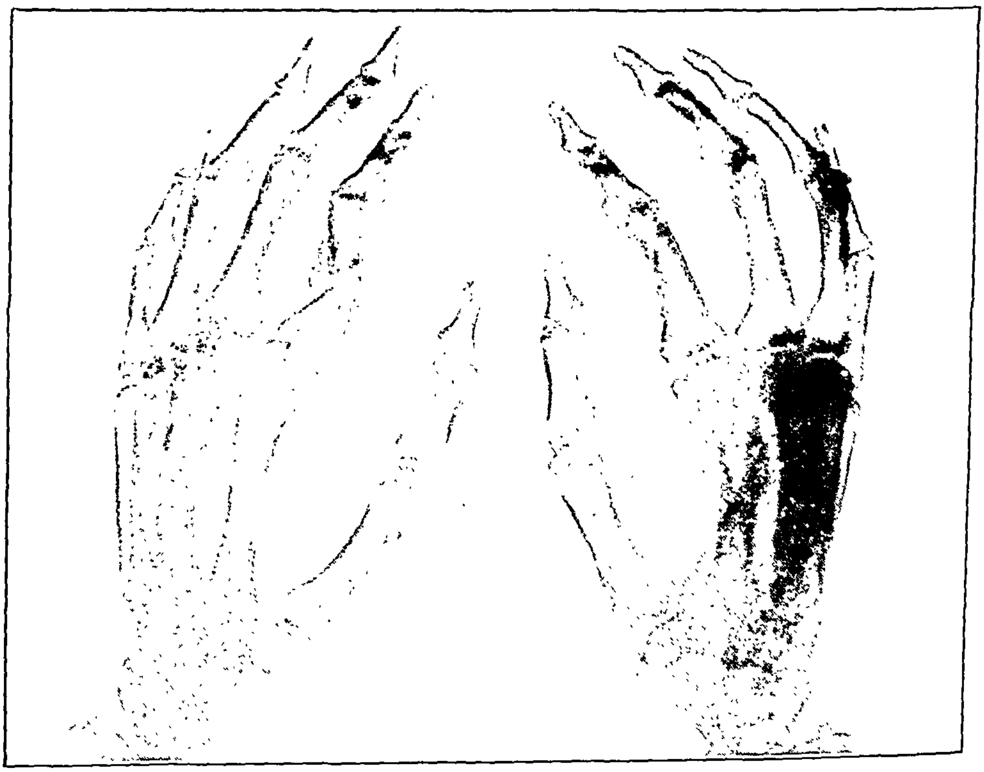

Fig. 4

The laboratory findings were:

Urine—normal.

Feces—no ova nor parasites on repeated examinations.

Blood:

Smears showed no malarial plasmodia nor other blood parasites.
Hemoglobin—80 per cent.
White blood count—6,800.
Red blood count—4,480,000.
Neutrophils—62 per cent.
Lymphocytes—34 per cent.
Eosinophils—4 per cent.
Wassermann—negative.

Spinal fluid Wassermann—negative.
Serum calcium—normal.
Complement-fixation test for gonococci—negative.
Quantitative tuberculin test—negative.
Metabolism rate—normal.

A roentgenographic study of the various parts of the skeleton made by Dr. Pomeranz showed the following: mild scoliosis of the dorsal spine with no destructive or productive process in any of the vertebrae; no changes in the ribs; moderate thinning of the bones of the vault of the skull with no erosions; fontanelles closed. The pelvis revealed normally formed bones of normal structure. Both feet showed complete fractures of the shafts of all the metatarsals with excess and irrregular new bone formation; a plantar angular deformity was present, also old fractures of the proximal phalanges of the second and fourth toes with partial absorption of the fragments. There were old fractures of the right tibia and left fibula. The right hand revealed united fractures of the second and third metacarpals and the left a united fracture of the proximal phalanx of the second finger with excess and irregular new bone production. Old united fractures of the ulnae in the distal thirds with excess bone were evident. The proximal phalanges showed cortical thinning and some medullary expansion. The shafts of the humeri were negative. The lower extremities revealed a peculiar moth-eaten erosion of the anterior surfaces of the shafts of the tibiae, not present in the upper extremities.

The information obtained from the history and examination of the patient, the presence of several fractures which were never suspected by the patient, and the peculiar x-ray picture of the skeleton reveal rather an unusual condition; the differential diagnosis presents difficulties.

Idiopathic fragilitas ossium, osteomalacia, Schulze's marble-bones disease, osteoporosis, rickets, and neurotrophic, parasitic, and neoplasmatic pathology could be considered.

However, the history, as well as the late appearance and peculiar localization of the fractures speak against fragilitas ossium. The normal condition of the spine and pelvis, the occurrence of fractures long after pregnancy, and the x-ray findings make osteomalacia improbable. Schulze's disease presents an entirely different roentgenogram. Repeated laboratory and clinical examinations did not disclose the presence of any chronic or parasitic infection; no signs of multiple neoplasmata nor of a neurotrophic disease were found.

RUPTURE OF THE BICEPS TENDON

BY H. D. SONNENSCHEIN, M.D., NEW YORK, N. Y.

Rupture of the long head of the biceps is a rather common injury. Many times it is productive of no special symptoms and is found accidently on general examination of the patient. Ruptures of the short head are rarely seen. Tearing off of the tendon where it inserts into the radius at the elbow joint is unusual.

In the *British Medical Journal* for April 11, 1931 (I, 611), Platt reports one case. The similarity in symptoms, findings, and method of repair prompts me to add the following case to the literature.

A. D., male, truck driver by occupation, aged twenty-nine, was admitted to the Hospital for Joint Diseases on September 21, 1931, service of Dr. Leo Mayer.

Family and past history irrelevant.

Present illness: On the evening of September 18, 1931, while the patient was lifting up on the crank-handle of a truck, he felt two sudden snapping sensations in the right cubital region of the arm, accompanied by a twinge of pain. He was unable to flex the elbow or to supinate the forearm without pain. He lost power in the arm and had difficulty in supporting the flexed forearm. He noticed also that it was difficult to "make a muscle" on the right side.

Physical examination: White, young adult male, not acutely ill. He still complained of pain.

Extremities: Both lower and left upper negative. Right upper extremity: A fullness about the lower aspect of the right arm with a smoothing out of the normal biceps contour. The elbow angulated at 140 degrees, the wrist held in mid-pronation. An attempt at full pronation was painful. Flexion at the elbow was painful but could be performed. The biceps was felt to contract when the forearm was flexed. There was a marked tenderness over the right cubital fossa. The bicipital tendon could be felt, though in contraction it was not as tense as the left biceps. The mid-portion of the muscle was not tender. Measurements were as follows:

Right arm	11¾ inches	Left arm	10⅝ inches
Right forearm	11⅞ inches	Left forearm	11¼ inches

Flexion of the right forearm against resistance was about eighty per cent. of the strength of the left. There was tenderness over the lower half of the biceps muscle. There was an apparent defect in the continuity of the biceps at a level of about one inch above the elbow joint. Some fibers of the tendon were felt.

Procedure: Exploration and suture.

Diagnosis: Ruptured biceps tendon—right.

Operative note—Dr. Sonnenschein—September 23, 1931: A four-inch incision was made to the front of the elbow joint above and below the flexion line, going through the skin and subcutaneous tissue. The torn end of the biceps tendon was lying free in the wound. This was completely severed from its attachment to the radius. By careful dissection the point of insertion on the radius was discovered and a large drill hole placed through this portion of the radius. A trap door was lifted up, the tendon placed in it and fastened around. The wound was closed. The arm was put up in acute flexion. That which on palpation was believed to be the tendon was found to be the partially torn bicipital fascia. There were no tendon fibers attached to the tubercle of insertion at the radius.

The dressings were removed at the end of eighteen days. The operative wound healed by primary union. The patient returned to work at the end of six weeks. When seen in the out-patient department two months after the operation he had made a complete recovery.

RESTORATION OF BONY DENSITY AND CONTOUR FOLLOWING EXTREME ATROPHY AND COLLAPSE OF THE FIFTH AND SIXTH CERVICAL VERTEBRAE

BY SETH SELIG, M.D. AND BENJAMIN ELIASOPH, M.D., NEW YORK, N.Y.

The operative fusion of tuberculous spines has become one of the widely used orthopaedic procedures. However, there are many bone surgeons in this country and Europe who believe that fusion of the posterior halves of the vertebrae delays healing of a tuberculous osteomyelitis of the bodies of the vertebrae by preventing the jamming together of the diseased bodies. They argue that Nature's method of healing the disease is to bring about a jamming together of the affected bodies with subsequent synostosis of the bodies and true healing.

The following case is unusual because of the complete restoration of bony contour in two vertebrae that had been partially destroyed by an osteomyelitic process.

Mrs. T. J., aged fifty-one, married, mother of one child, was referred to me February 14, 1929, because of pain in the neck. The present illness began two weeks previously with malaise and generalized pain in the shoulders and neck. The temperature was never more than a degree above normal and a diagnosis of grippe was made and the patient advised to remain in bed. In a few days all the vague generalized pains had disappeared except the neck pain. This had become quite severe, localized, and interfered with her sleep.

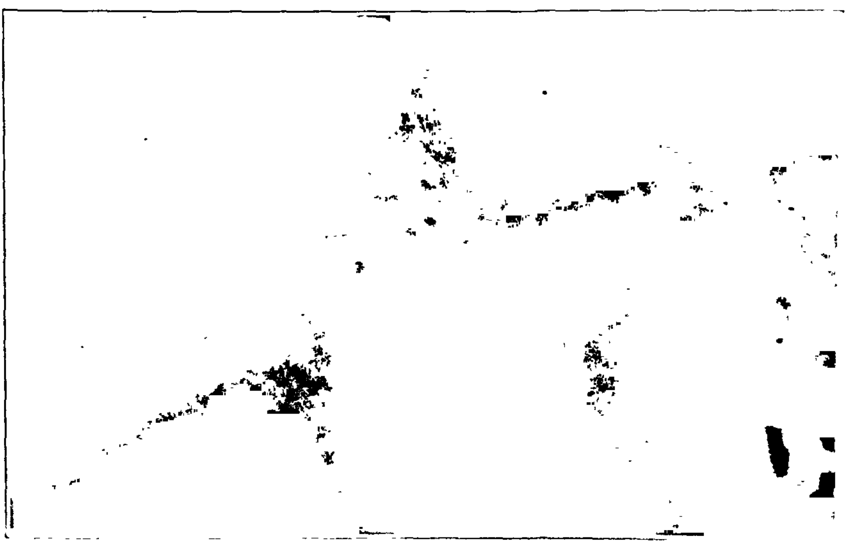

FIG. 1

Roentgenogram taken before reduction. Shows collapse of the fifth and sixth cervical vertebrae. Bony debris can be seen a quarter of an inch anterior to the collapsed bodies. (February 22, 1929.)

FIG. 2

X-ray taken after reduction and immobilization in plaster for ten weeks. Complete restoration of bony contour of the bodies and alignment of the cervical spine. Disc between the fifth and sixth cervical vertebrae has been destroyed, with consequent bony ankylosis between the involved vertebrae. (May 5, 1929.)

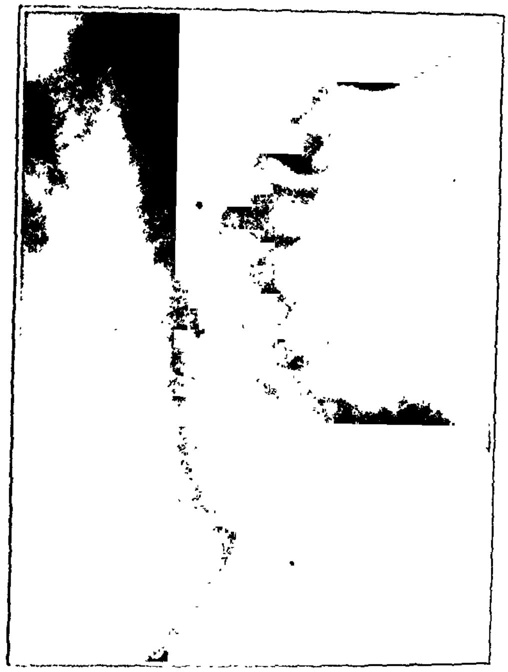

FIG. 3

X-ray taken six months after the onset of the illness. The only change since the previous plate is the increase of calcium deposition in the involved vertebrae. (August 22, 1929.)

Past history: Measles when a child; hysterectomy for benign fibroids eleven years previously. Except for an occasional mild attack of nasopharyngitis, her health had been excellent until the onset of her present illness.

The physical examination was negative except for the local condition. The neck was rigid and flexed. There was resistance to all motions of the cervical spine, but especially to extension. Lateral motion was almost gone, and rotation of the head was painful but could be performed slowly. There was tenderness over the spinous processes of the fifth and sixth cervical vertebrae. A tentative diagnosis of acute cervical arthritis was made and diathermy treatment instituted. The patient's condition rapidly grew worse, the flexion of the cervical spine became marked, and an x-ray was taken. The lateral view (Fig. 1) showed a destruction of the fifth and sixth cervical vertebrae with resultant kyphotic deformity. The intervertebral disc between the fifth and sixth cervical vertebrae had been destroyed. On the film some bony debris could be seen about a quarter of an inch anterior to the fifth cervical vertebra.

The diagnostic possibilities that suggested themselves were: tuberculosis; neoplasm, either primary or metastatic; tertiary syphilis; or osteomyelitis. Against the diagnosis of tuberculosis was the rapid progress of the disease (one month). In favor of it were the destruction of the disc and the debris visible anterior to the vertebrae. Against metastatic neoplasm were the absence of any primary growth after careful examination, and the destruction of the disc, and the fact that two adjacent vertebrae were involved. A primary neoplasm could not be ruled out. Against syphilis were the absence of any physical signs of lues, and a negative Wassermann blood reaction. The rapid onset and progress of the destruction could be explained by an osteomyelitis of the cervical vertebrae. Examination through the pharynx was negative.

Even if a positive diagnosis could not be made, the indications for treatment appeared clear. The patient was in constant agony and the head was now sunk forward on the chest. Any attempt at extension was resisted. An initial attempt to reduce the kyphos, with the patient sitting in a chair, was unsuccessful. A second attempt was made with the patient lying on her back, crosswise in bed, with the head and neck extending over the side of the bed and supported by an assistant. The patient had been rendered moderately analgesic by means of five grains of medinal every three hours for three doses and one-quarter of a grain of morphin by hypodermic injection immediately before the manipulation was begun. Slowly gravity was permitted to hyperextend the cervical spine, the process consuming ten minutes. With the head held in this position a plaster double shoulder and head spica was applied. When the plaster had hardened and the patient was lifted to a sitting position, the face was turned to the ceiling. The relief of the neck pain was almost immediate. The nerve root pains down the arms and over the shoulders (fifth, sixth, and seventh cervical nerves) persisted for some days, but then disappeared. The patient's appetite and general condition began to improve. The relief of pain was of some diagnostic value; pain due to a neoplasm, either primary or secondary, is rarely relieved by immobilization in plaster.

The plaster was permitted to stay on for ten weeks and then was bivalved and an x-ray taken. The film (Fig. 2) showed that the alignment of the cervical vertebrae had been completely regained, and that the bony contours of the fifth and sixth cervical vertebrae had also been restored. The disc had been destroyed and bony fusion had taken place between the diseased vertebrae. Movements of the neck were free and painless in all directions. No local tenderness could be elicited over the cervical spine.

Two and a half years have elapsed since the onset of the disease without any further symptoms or signs of any recurrence. Subsequent x-rays (Fig. 3) show no change other than increased calcification of the involved vertebrae.

The most likely diagnosis, in view of the rapid onset and rapid and complete healing, is a non-suppurative osteitis or osteomyelitis of the fifth and sixth cervical vertebrae, which healed with restitution to integrity after reduction was performed and weight-bearing was removed.

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This illustration of an unusually extreme callus has been sent to *The Journal* by Dr. C. F. Eikenbary of Seattle, and represents the end result of a fracture of the leg of a pheasant, which occurred some years previously. This x-ray is interesting, demonstrating a very extensive and very firm callus thrown about the area of overlapping and displacement. It shows that nature has an efficient but not necessarily cosmetic repair process.

THE CONSERVATIVE TREATMENT OF INCOMPLETE DISLOCATION OF THE ACROMIOCLAVICULAR JOINT*

BY AARON H. TRYNIN, M.D., BROOKLYN, N. Y.

Dislocation of the acromial end of the clavicle is not an infrequent injury. Treatment should be begun at once with complete and prolonged retention of the bones constituting the joint. The conservative method of treatment of incomplete dislocations has not been satisfactory. It is the opinion of most surgeons that open operation must be employed to obtain a good functional or cosmetic result. It is the purpose of this paper to present an apparatus which satisfies all the requirements in treating this condition conservatively.

The object of the treatment is to overcome the weight of the arm which draws the acromion downward and inward and away from the clavicle and to counteract the reflex contraction of the trapezius which draws the clavicle upward. The acromion must be forced upward and outward and the end of the clavicle pressed in the opposite direction. Even with inadequate reduction the function may not be disturbed but a considerable cosmetic disfigurement results. Many methods have been described and used to meet these conditions; reference is made to some of these in the bibliography.

To treat this condition satisfactorily an apparatus should be employed which will elevate the acromion, depress the clavicle, and at the same time permit freedom to the motions of the shoulder and elbow joints. The advantages to the patient in having free use of his

Fig. 1

The Böhler clavicular splint.

*From the Service of Dr. S. Kleinberg, Hospital for Joint Diseases, New York.

Fig. 2
The splint applied with sufficient padding to protect the skin.

Fig. 3
Posterior view.

extremity while the reduction is being maintained are quite evident. Böhler[1] has been using a special splint for treating fractures of the clavicle which the writer has used successfully in three cases of incomplete dislocation of the acromioclavicular joint. It satisfies all the requirements for the proper management of this condition (Fig. 1).

The splint consists of a board (*a*) thirty centimeters long, fifteen

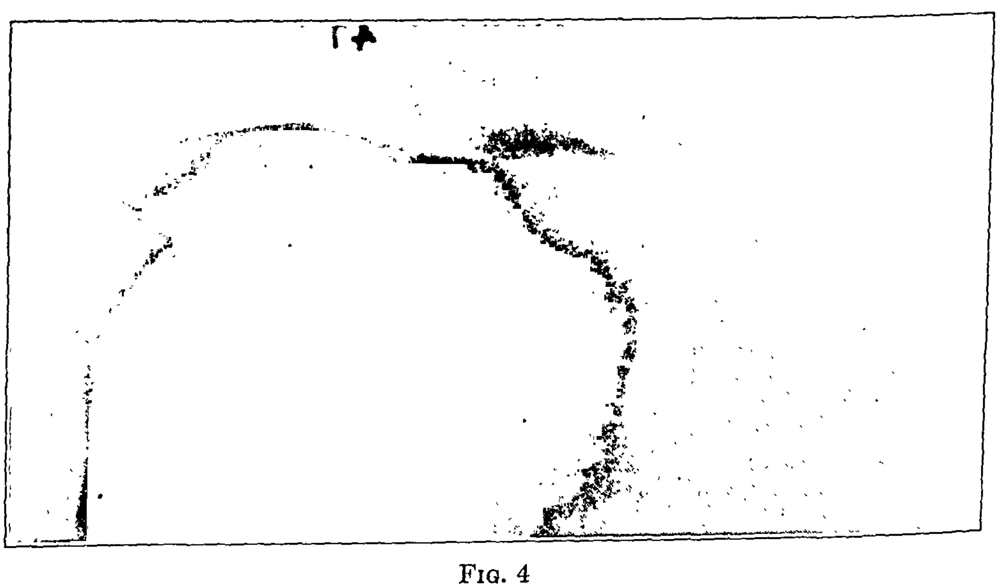

Fig. 4
Incomplete dislocation of the right acromioclavicular joint with elevation of the clavicle and widening of the joint space.

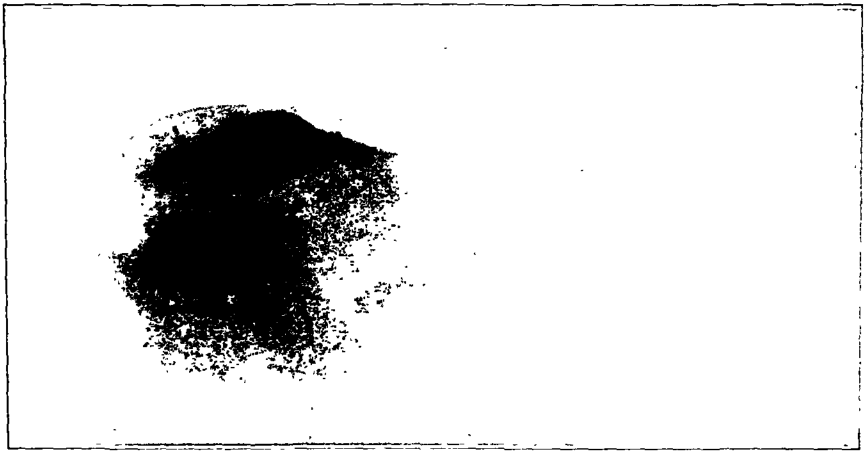

FIG. 5
Same case after reduction and application of the splint.

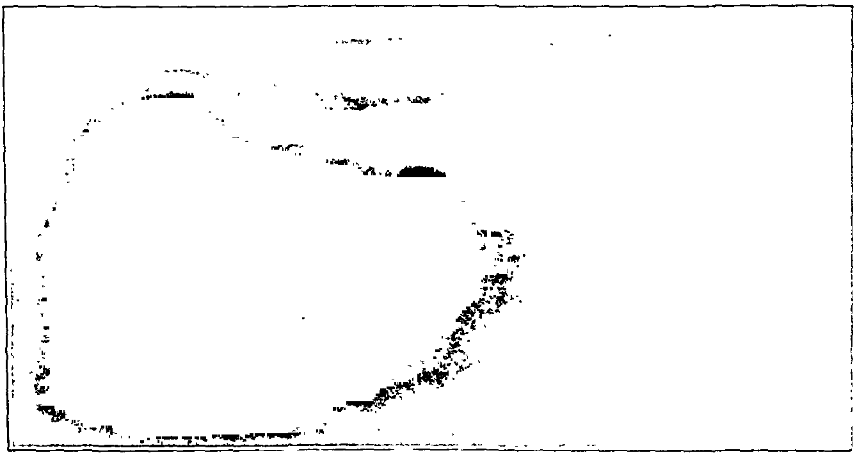

FIG. 6
Eight weeks after injury—two weeks after removal of the splint. Reduction maintained.

centimeters wide, and five centimeters thick; the part fitting into the axilla is smoothed into a Gothic arch in order to fit the concavity of the axilla. Two malleable iron ribbons (*b* and *c*), fifty by four by four-tenths centimeters, with two short belts made of webbing, are fastened to the main part of the splint and are used to fasten the splint to the trunk. A third webbing (*d*), attached to the splint, is fastened over the normal shoulder and is used to raise the injured shoulder. A fourth belt (*e*) with a buckle is introduced under the lower iron ribbon and is used to press the clavicle down. All parts are well padded and under the webbing used to exert pressure upon the clavicle a felt pad is placed. After a local injection of about five cubic centimeters of two per cent. novocain, the dislocation is reduced and the splint applied.

Böhler points out several advantages of his splint in the treatment of fractured clavicles which apply equally well to the treatment of this condition. The patient is extremely comfortable if the splint is properly applied (Figs. 2 and 3). The shoulder joint, elbow, and fingers are free. The patient can immediately make use of his hand in all light occupations without displacing the alignment of the clavicle and acromion. Atrophy of the muscles and stiffness of the joints are avoided. If there is pressure in the axilla against the blood vessels and nerves, and the patient feels a tingling sensation in his fingers, he need only raise his arm and at once release the pressure. Böhler does not mention the use of this apparatus in the treatment of acromioclavicular dislocations.

The following x-rays are illustrative of a typical case treated by this method. The reduction obtained immediately after application of the splint (Fig. 5) was maintained eight weeks after the injury,—two weeks after removal of the splint (Fig. 6). At that time all motions about the shoulder were free and painless. The patient had free use of his extremity during the period of treatment.

COMMENT

1. The conservative treatment of incomplete dislocation of the acromioclavicular joint has not been satisfactory.

2. Many surgeons advocate open operation in all cases of incomplete dislocation because of the poor results obtained.

3. An apparatus should satisfy three requirements,—traction downward on the clavicle, pressure upward on the acromion, and freedom of motion of the extremity.

4. Böhler's clavicular splint used in the treatment of fractures of the clavicle has been adapted for the treatment of incomplete dislocation of the acromioclavicular joint with successful results.

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SPECIAL SAW AND RETRACTOR FOR PLASTIC OPERATIONS ON THE FEMUR

BY G. KENNETH COONSE, A.B., M.D., COLUMBIA, MISSOURI

Department of Orthopaedic Surgery, University of Missouri

The relationship of the various structures about the femur renders it practically inaccessible to motor-driven rotary saws of the Albee type. The ordinary methods of osteotomy require multiple drill holes and the use of thin osteotomes. This often results in splintering of the bone. Considerable operative shock is often associated with this procedure and there is always an increased likelihood of fat embolism. To minimize these risks and simplify Z osteotomy of the femur, a special saw and retractor have been devised and used with uniformly good results on the Orthopaedic Service of the University Hospitals (See Figure 1).

The saw blades are made from specially tempered steel of the type ordinarily used in a metal hack saw. The blade tapers from its proximal end distally, after the fashion of a carpenter's key-hole saw. The width at the distal end is slightly less than one-eighth of an inch and the width at the proximal, or handle, end is just under one-half inch. A small metal bead at the tip of the saw protects the tissues when it is introduced through the drill hole, and to a certain extent while it is being used. It is only necessary to drill two holes in the shaft of the bone as far apart as is indicated in the

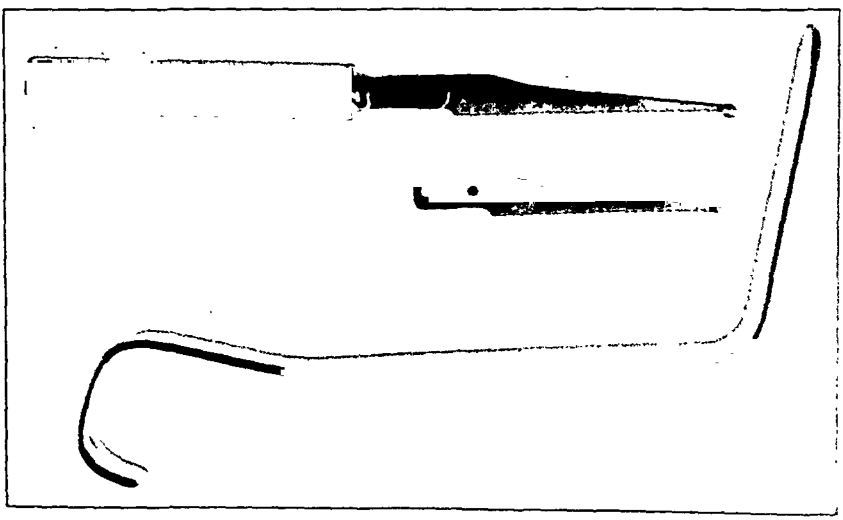

FIG. 1

Showing saw with interchangeable blade and retractor.

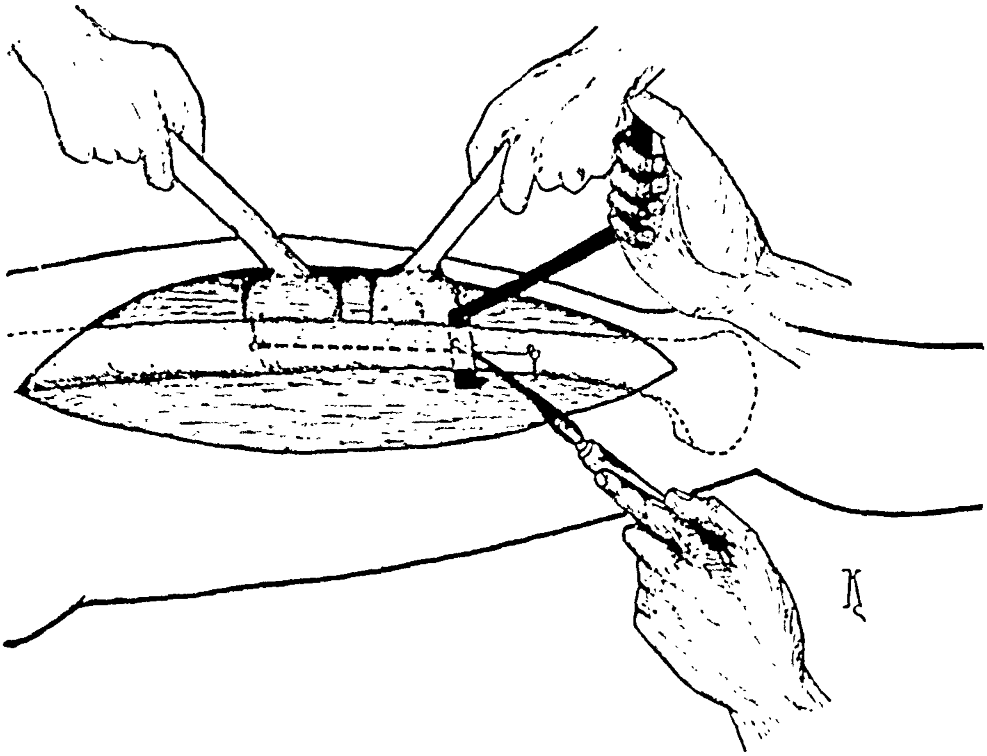

FIG. 2
Illustration shows the application of the instruments in Z osteotomy of the femur.

particular case at hand. The saw is introduced through the drill hole and a cut made in the long axis of the bone until the distal drill hole is reached (See Figure 2). The blade is then turned upward at a right angle and the bone sawed through. The saw is next reinserted at the opposite end and a cut made downward to complete the osteotomy. The metal bead prevents it from being drawn out at each stroke.

A new type retractor has been developed for use with the saw (See Figure 1). This retractor is introduced over the lateral surface of the femur and serves to displace the vessels, nerves, and muscle tissue medially. In this way sufficient space may be obtained for efficient action of the saw. The metal tip comes in contact with the retractor during each stroke, thus preventing possible harm to the important structures. The retractor is moved along synchronously with the saw.

These two simple instruments have greatly reduced the difficulty of Z osteotomy of the femur in our hands, and we report them that they may be made available to others doing plastic work with bone.

BONE SKIDS

BY R. M. YERGASON, M.D., F.A.C.S., HARTFORD, CONNECTICUT

Fracture of a shaft of a long bone requiring open operation has sometimes proved very difficult to reduce, especially in short, stout patients. Not only is it hard to reduce the overriding and bring the fragments end to end, but, having done this, it is often much more difficult to shift one fragment upon the other to make the irregular edges fit together exactly.

An assistant, holding retractors for visibility only, is of no help in replacing the fragments, which operation requires more than the two hands of the surgeon for its accomplishment.

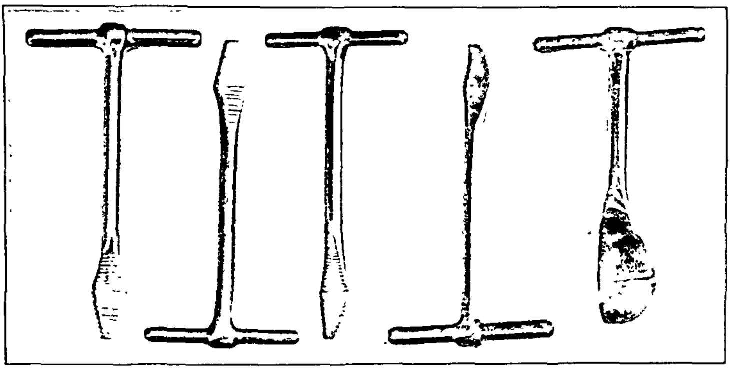

Fig. 1

Two or three of the bone skids, illustrated, can be inserted behind the fragments to serve the double purpose of lifting out the bone and holding back the muscles. The thin edge of another skid may be introduced between the ends of the fragments and then turned so that the bones are separated by the width of its blade. The action is the same as that in opening a box with a screw-driver, the blade of which is pushed between the boards and then turned so that its greater width separates the cover.

These skids enable gross or small adjustments of the fragments to be made with surprising ease and speed.

There are four skids, each one milled or notched along the edges so that the bone fragments will not slip off when the skid is turned. Two of them are straight, quite like screw-drivers, the other two being curved on the flat, the better to scoop in the bone when making gross replacements. The curved ones have transverse grooves on the convex sides to prevent slipping, but are smooth on the concave surfaces.

After the fracture has been perfectly reduced, it may be found to have such a tendency to displacement that some form of internal splinting, or other device, becomes necessary to maintain reduction. With fractures that are transverse, the use of the "staple" of Dr. W. B. Carrell[1], an invention which deserves the highest praise, is certainly the method of choice. To install it, a small hole is drilled in each fragment and the staple pounded in. This tends to displace the fragments, as would undue pressure from a drill or screw-driver in using a Lane plate.

To prevent displacement of this kind was made the fifth instrument in the illustration, which is simply a smooth scoop, one and a quarter inches wide. This is slipped behind the fracture and is held firmly against the bone as a sort of anvil upon which to work.

By the use of these skids and Dr. Carrell's staple, the writer recently accomplished an open reduction of the upper third of the femur in just forty minutes from entering to leaving the operating room (The spica included the opposite thigh).

Perfect reductions are obtained by this method. No second operation to remove the staple is necessary. Hence it would seem that the treatment of these difficult fractures has been somewhat simplified.

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News Notes

The Forty-Sixth Annual Meeting of the American Orthopaedic Association will be held in Toronto on June 15, 16, 17, and 18.

On the first day, Wednesday, June 15, a clinical program will be provided by the Toronto members of the Association, and in the late afternoon the annual golf tournament will take place at the Royal York Golf Club.

The regular meetings will be held in the Theatre of Hart House at the University of Toronto. An excellent scientific program is being arranged, concerning which members will receive an announcement some time in April.

The Spring Meeting of the British Orthopaedic Association will be held in Nottingham on April 22 and 23. It has been decided also to hold a one-day meeting in London on July 27, the day before the meeting of the British Medical Association.

The eleventh annual meeting of the **International Society for Crippled Children** will be held at Rochester, New York, April 17 to 20.

A recent statement from the **California Society for Crippled Children** tells of the forming of a new chapter in Alameda County, making ten chapters in the state.

Dr. Michael Hoke has been appointed Chief Surgeon to the Georgia Warm Springs Foundation, Warm Springs, Georgia.

Dr. William Barnett Owen of Louisville, Kentucky, announces the association with him and Dr. Robert Lee Woodward of Dr. Richard T. Hudson. Their office is at 822 Heyburn Building.

Dr. Harald Nilsonne of Stockholm, Sweden, a member of the Advisory Editorial Staff of *The Journal*, has been appointed General Secretary for the Northern Orthopaedic Association, succeeding Dr. Bentzon.

The Milwaukee Orthopaedic Club met on January 13. Dr. John W. Powers was elected president for the coming year and Dr. Lemuel Smith, Secretary and Treasurer.

The second Walter M. Brickner lecture at the **Hospital for Joint Diseases** in New York City was given on February 9. The lecturer was Dr. Albert A. Epstein and his subject, Surgery in the Diabetic.

The following post-graduate students were successful in the examination for the degree of **Master of Orthopaedic Surgery (M. Ch. Orth.)**, held in Liverpool in December 1931:

John Lawler Donelly, M.B., Ch.B. (Liverpool), Liverpool, England.
Thomas Smith Donovan, M.B., Ch.B. (Birmingham), F.R.C.S., Birmingham, England.
Alexander Robert Hamilton, M.B., Ch.B. (Sydney), Sydney, New South Wales.
Eric Newton Wardle, M.B., Ch.B. (Liverpool), F.R.C.S., Heswall, Cheshire, England.

Dr. Gosta Sjogren, formerly assistant to Prof. Patrik Haglund of Stockholm, Sweden, has been appointed Chief Surgeon of the new orthopaedic institution which has been opened at Harnosand. This will be the regional orthopaedic hospital for the north of Sweden. It includes an out-patient department, a clinic of one hundred beds with work-shop for the manufacture of orthopaedic appliances, and training school for various trades which accommodates one hundred pupils.

On March 11 the new **Surgical Institute for Children** in Chicago was formally opened and an interesting clinical program was presented under the direction of Dr. H. B. Thomas. This one-hundred bed hospital is affiliated with the College of Medicine of the University of Illinois and the Department of Public Welfare. The new Medical Laboratory building is completely equipped for research on orthopaedic problems,—such as hemophilia, dystrophy, congenital fractures, etc.

The newly elected officers of the **Los Angeles Orthopaedic Society** are as follows: H. Waldo Spiers, President; Steele F. Stewart, Vice-President; Vernon P. Thompson, Secretary and Treasurer.

The first meeting of the year was held at the Johnson Café on Monday evening, March 14. The following program was presented: Dr. John C. Wilson gave a résumé of the recent Fracture Conference. Dr. Steele F. Stewart showed some interesting lumbo-sacral roentgenograms. Dr. S. S. Mathews demonstrated wire traction in the treatment of fractures.

The Society meets the second Monday in March, May, September, November, and January.

The Chicago Orthopaedic Club met at the Edward Hines Veterans' Hospital, in Maywood, Illinois, on the evening of February 12. An interesting program was presented, including papers by the following:

Metastatic Carcinoma of Bone (Primary Focus in the Prostate). Dr. B. F. Ward.
Blastomycosis Infection with Skin Ulcerations and Metastatic Bone Involvement. Dr. B. F. Ward.
Discussion by Dr. Charles Parker and Dr. F. A. Chandler.
Fracture of the Astragalus. Dr. Robert A. Ritter.
Ununited Fracture of the Forearm. Dr. Robert A. Ritter.
Discussion by Dr. Philip H. Kreuscher, Dr. Arnold Schimberg, and Dr. Edward L. Compere.
Osteo-Chondritis Dissecans. Dr. Philip H. Kreuscher.
Discussion by Dr. F. Seidler, Dr. C. N. Pease, Dr. F. G. Murphy, Dr. Sidney Sidemon, Dr. E. L. Compere, and Dr. F. A. Chandler.
The Maggot Treatment of Chronic Osteomyelitis. Dr. S. K. Livingston.
Discussion by Dr. Leo M. Czaja, Dr. E. L. Compere, Dr. Philip H. Kreuscher, and Dr. L. H. Prince.

The Twenty-Seventh Congress of the Deutsche Orthopädische Gesellschaft is to be held in Mannheim on September 5, 6, and 7, under the presidency of Prof. Adolf Stoffel. The first day will be devoted to the consideration of "The Pathophysiology and Treatment of Fracture of the Neck of the Femur", and the second day to "Internal Injuries of the Knee Joint". Both of these subjects will also be considered with reference to industrial surgery. The afternoon of the second day will be given up to a discussion of "Plastic Surgery of the Acetabulum". The subject for the third day will be "Malunion of Fractures".

The Twenty-Second Congress of the Italian Orthopaedic Society was held in Milan, October 25 to 27, 1931, under the presidency of Prof. Riccardo Galeazzi. In his presidential address Prof. Galeazzi paid tribute to the generous financial aid which had been given to the University of Milan by the Fascist government and expressed appreciation for the additional advantages provided for the cause of science.

The program of the Congress included two main themes:

1. Cysts and Pseudocysts of the Long Bones, presented by Prof. Gherardo Forni of Bologna.

Following his address, several other members spoke on related subjects.

2. The Orthopaedic Treatment of Conditions Resulting from Infantile Paralysis, address by Prof. Pietro Palagi, Florence.

Others also spoke on the same subject, giving their results of various methods of treatment. Following the consideration of these two main subjects, various other papers were presented:

Heliotherapy in the Treatment of so called Surgical Tuberculosis, by Prof. A. Rollier of Leysin, Switzerland;

The Etiology of Scoliosis, by Prof. Galeazzi.

Short papers were presented also by the following:

Dr. Giovanni Giuliani of Parma, Prof. Luigi de Gaetano of Naples, Prof. Sanzio Vachelli of Cortina d' Ampezzo, Prof. Giuliano Vanghetti of Empoli, Dr. Carlo Marino Zuco of Rome, Dr. Enrico Busi of Brescia, Dr. Gioffrede Giraudi of Milan, Dr. Giuseppe Tancredi of Rome, Prof. Giuseppe Annovazzi of Milan, Dr. Rosario Marziani of Milan, Prof. Enrico Ettorre of Milan, Dr. Aldo Vigano' of Milan, Dr. Edmonde Venezia of Rome, Dr. Antonio Mezzari of Valdoltra, Dr. Siro Luigi Carnevali of Milan, Dr. Carlo Zangheri of Valdoltra, Dr. Giuseppe Rotolo of Milan, Dr. Ettore Rinaldi of Trieste, Prof. Giulio Faldini of Parma.

Current Literature

LES TUMEURS DES OS. By J. Sabrazès, G. Jeanneney et R. Mathey-Cornat. Paris, Masson et Cie., 1932. 80 francs.

The subject is presented with the characteristic thoroughness which is found in the publications of Masson et Cie. The introductory remarks and preface will be found of interest in the brief survey of the present status of this subject, as well as the tracing of the development of the knowledge which has been acquired during the recent decades. Three of the classifications which have been proposed are presented in this portion of the book, and the author then gives the grouping which he has proposed, which is simple, and which he uses in his work, and which classification is based upon the findings by clinical observation, pathology, anatomy, and radiology.

He makes four divisions, treating the benign osseous tumors, giant-cell tumors, malignant tumors—both primary and secondary—and a chapter is devoted to the consideration of the metastatic bone growths. Each of the affections is considered with reference to the clinical pathology and the x-ray evidence, as well as the treatment. The clinical part of each is treated in detail. With each of the divisions the general history, etiology, pathology, and clinical course, with the evidence for diagnosis, are well described. In the first portion the benign tumors—osteoma, exostosis, fibroma, lipoma, myxoma, angioma—are taken into consideration. In the giant-cell group, the cysts and osteitis fibrosa are mainly considered. In the portion devoted to malignant types, the divisions are made of Ewing's sarcoma, angio-endothelioma, multiple endothelioma, myeloma, chloromyeloma, and periosteal fibrosarcoma. The portion on the metastatic groups is of particular value in view of the importance and difficulty of these manifestations. These are considered mainly with reference to their location. The book is fully illustrated with excellent reproductions of x-rays of the various bone tumors and has a complete bibliography of the literature pertaining to the subject.

FUNDAMENTALS OF ORTHOPAEDIC SURGERY IN GENERAL MEDICINE AND SURGERY. By Robert B. Osgood, M.D., F.A.C.S., and Nathaniel Allison, M.D., F.A.C.S. New York, The Macmillan Company, 1931. $3.00.

This title may be a little misleading, for the book actually covers more than the fundamentals of the various subjects, giving instead an excellent résumé of the more essential elements of each of the affections discussed, including treatment. It gives the student the basic knowledge necessary in a school course, from which he can proceed to more detailed knowledge in each subject.

The first three chapters are devoted to the general consideration of the conditions with reference to the bones and joints and the pathology, and the remaining chapters are devoted to the special and more important subjects. The simple description of the process and the result of invasion of bone by bacteria is quite worthy of imitation in comparison with the complicated scientific descriptions so often given the student.

The next chapters are devoted to a consideration of tuberculosis and anterior poliomyelitis and to the brief consideration of the essential features which are important to the student and the general practitioner, and are suggestive to them in their further study. The book contains also a chapter on the relation of orthopaedic surgery to industry, which is very well advised because a very large number of cases of accidents are of orthopaedic interest.

Teachers may very well read the preface with profit. It is of particular value, for the method which it discusses has had the test of experience, and has been perfected by its use over a number of years.

Lehrbuch der Röntgendiagnostik. By H. R. Schinz, W. Baensch, und E. Friedl. Leipzig, Georg Thieme, 1932. 220 marks.

This work consists of two volumes, containing 1623 pages, 2714 illustrations and 5 photographic plates. It is the third edition and has been completely revised and enlarged. In addition to the above authors it contains contributions by M. Holzmann, A. Hotz, O. Jüngling, E. Liebmann, E. Looser and K. Ulrich.

The first volume is devoted entirely to a study of the skeleton. The introductory chapter is an outline of physical laws and technical principles encountered in roentgenography. Following this is a discussion of the structure of normal bone and its appearance in the x-ray photograph, together with the enumeration of many pitfalls which may be avoided by correct interpretation. There is also a concise description of the principal changes seen in bone tissue,—atrophy, osteolysis, necrosis, and sclerosis.

The chapter on fractures is a general discussion of the bone changes,—process of healing, pseudarthrosis, infections, and transplants. Special fractures are not considered. The infectious diseases of bone include periostitis and osteomyelitis. Tuberculosis of bones and joints is never diagnosed with certainty until it is proved by demonstration of the bacilli, animal inoculation, or microscopic examination of the tissues.

Bone tumors are classified and described as benign (solitary bone cysts, benign solitary giant-cell tumor, fibroma and myxoma, solitary chondroma, osteochondroma and osteoma, and hemangioma) and malignant (osteogenic sarcoma, Ewing's sarcoma, myeloma, extraperiosteal sarcoma, and metastatic extra-osseous tumors).

Diseases of the joints are listed as traumatic conditions, infectious arthritides, non-infectious arthritides or arthroses, neoplastic conditions or arthromata. Joint changes are further described as they occur in ankyloses, arthroplasties, and regenerative processes.

Congenital and acquired deformities and disturbances of growth are presented quite fully. One chapter is devoted to a description of diseases of the head, including the skull, sinuses, jaws, and teeth. In a special chapter on the spine are mentioned the more common forms of congenital anomalies, fractures, and dislocations.

There are, further, discussions of ventriculography and myelography, aseptic necroses of bone, systemic metabolic diseases of bone, and localization of foreign bodies.

In general, it may be stated that the authors have very successfully fulfilled their purpose of producing a textbook of roentgen diagnosis. This work is written in a very clear and simple language, sufficiently complete, but entirely free from discussions which are controversial in nature. The authors, on the basis of large amounts of material, speak with the certainty and authority which are acquired only by a wide experience.

A very valuable feature is the large number of unusually clear illustrations. Tables and charts are inserted occasionally to help the reader. Quotations from other sources are rare in the text, but references are given freely at the ends of the chapters. Case reports and discussions of clinical features are omitted. The reader is never allowed to forget that the first purpose of roentgenography is to discover the characteristics of tissues, and that diagnosis of disease is dependent on the observer's ability to interpret the findings on the basis of anatomy and physiology. The volume embodies all the desirable qualities of a good reference book and, as the writers intended, should be of value "not only to the radiologist, but also to the general practitioner and the specialist".

Volume II consists of a description of the roentgenographic aspects of the internal organs, including the respiratory, circulatory, gastro-intestinal, and urinary systems. In addition, there is a chapter on x-ray study of obstetrical and gynecological conditions.

Atlas de Radiographie Osseuse. Squelette Normal. By G. Haret, A. Dariaux, et Jean Quénu. Ed. 2. Paris, Masson et Cie., 1932. 186 pages. 200 francs.

In 1927 Masson et Cie published the "Atlas de Radiographie du Système Osseux Normal" by G. Haret, A. Dariaux, and Jean Quénu, which was announced as the first of a series. This was followed in 1931 by two volumes devoted to abnormal conditions: "Lésions Traumatiques" by the same authors, and "Lésions Non-Traumatiques" by Étienne Sorrel and Mme. Y. Sorrel-Dejerine. The value of these two volumes was very

greatly enhanced by the possible comparison with the normal skeleton shown in the first book. The roentgenograms were so taken as to show the positions which experience has proved to be the most valuable and practical in the study of these lesions. In this way, an estimate of the pathological conditions is most easily made.

This second edition of the first volume has followed the same general plan of presentation. Many of the original illustrations are reproduced and a large number of new cuts are added. The skeleton of the adult is shown in four sections: upper and lower extremities, feet and head. Two illustrations of each position are outlined to indicate the special features to be regarded in the study of the various lesions. In this latter are shown the views of the foetus *in utero* at five, six, eight, and nine months, the new-born, and the essential portions of the skeleton of a child at the ages of one, three, six, eight, ten, and fifteen years. A series of roentgenograms are shown, demonstrating the points of ossification and the supernumerary bones. The cuts are uniformly clear and large, many occupying a full page. The book is adapted for every surgeon who has to deal with the osseous system.

Om den Medfødte Klumpfod og dens Behandling. (On Congenital Club-foot and its Treatment.) By Dr. A. Monberg. Copenhagen, Gads Forlag, 1931.

The author submits a brief account of the occurrence, heredity, and etiology of club-foot on the basis of current views,—a patho-anatomical survey on the basis of skeletal and clinical material. He gives a detailed account of the different methods of treatment to which club-foot has been subjected.

The work is based upon an end-result study of 228 treated cases of congenital club-foot from the Orthopaedic Clinic, Copenhagen, Prof. Slomann's private clinic, in Copenhagen, and the Orthopaedic Clinic, Oslo. The results of the examination of these cases have led to the following conclusions:—

Treatment by forcible correction and plaster is used in young children and may be commenced as early as possible. At the end of the first year of life, the daily manipulations should be terminated by forcible correction under anaesthesia. Tenotomy of the Achilles tendon in correction of the equinus position should be carried out and prolonged after-treatment is necessary. Phelps' operation is condemned. In older recurrent cases, resource may be had to osseous operations, the choice being made between astragalectomy and cuneiform osteotomy. The former should be used when changes are localized to the astragalus and when subluxation is present; the latter, when the deformity is localized to the forepart of the foot. If the patient comes for treatment as late as after twenty years of age the author considers amputation the only possible procedure.

Orthopedics in Childhood. By William L. Sneed. Philadelphia, J. B. Lippincott Company, 1931. $5.00.

A number of textbooks have been written with the object of giving to the practitioner and to the general surgeon information necessary to enable him to give the first simple treatments in the various orthopaedic affections, and the object of such a book is always to be commended, for there are probably few specialties in which the various affections—particularly in the early stages—need more careful observation and attention than those met with in orthopaedic surgery. It is especially essential that men without much experience should have directions, if it is not possible for them to have training, in the methods of examination and in regard to the special symptoms and signs observed in these conditions. In this book this object has been kept in view; in fact, it is clearly so stated in the preface. It is not an attempt to convey to the well informed orthopaedic surgeon new methods or new knowledge, and, in avoiding this, the author has made a wise decision. The book is clearly written, the directions given are simple, and the essentials are very well brought out. The book is excellently illustrated, and the author has drawn upon his own experience and resources both for the text and for the illustrations.

TRAITÉ D'ANATOMIE HUMAINE. By P. Poirier et A. Charpy. Ed. 4. Paris, Masson et Cie., 1931. 130 francs.

A new edition of Traité d'Anatomie Humaine by Poirier and Charpy, entirely revised under the direction of Prof. A. Nicolas, will certainly have a welcome, for it has an established position in the medical and scientific world. The work consists of five volumes. Each division of this treatise on human anatomy is issued independently and can, therefore, be purchased as desired. This present volume, which has just appeared as the First Division of Volume I of the fourth edition, includes the consideration of general anatomy, the development of bone, the general structure of the skeleton, and in this special division the description of the anatomy of the cranium and its parts. The book is not simply descriptive anatomy, but a study of the subject of anatomy and its relation to the sciences, and occupies a unique position by its thoroughness and accuracy of detail.

Fifty-three pages are devoted to a consideration of general anatomy, including protoplasm, the cell, and the various tissue structures. Eighteen pages are then devoted to the development of bone. Both of these parts are edited by J. Verne and form the base with which the remainder of the various subjects are intimately connected. The main portion of this division of Volume I, by M. Augier, (584 pages with 305 illustrations) is occupied by the description of the skull with its various bones, their relation and articulation, and their development, as well as the variations found in their structure. The cranium is studied also as a whole and the variations seen in age, sex, and individuals are described. The dimensions of the various parts of the skull, with the methods of measurement, are described.

There is an introduction to this volume by L. Manouvrier. The illustrations are excellent and show care, for they were made under the personal supervision of the authors.

RÖNTGENDIAGNOSTIK DER KNOCHEN- UND GELENKERKRANGUNGEN IN TABELLENFORM. By Dr. Emmerich Markovits. With a foreword by Prof. Dr. Robert Kienböck. Leipzig, Georg Thieme, 1929. 159 pages. 14.40 marks.

The author has presented in this book the x-ray findings in the diseases of the bones and joints, taking each affection in order and considering it in connection with the anatomical parts usually involved. This presentation is comprehensive, so that the book can be consulted for practically all of the pathological conditions which are found. Although a book of this size permits the consideration of only the fundamental and most important features to come within its scope, yet this field is very well covered. The normal findings are fully given to aid in comparison and to guide in methods of interpreting. Outline drawings are shown, which serve to indicate the special areas which come under observation. The book is illustrated by 254 photographs of x-rays and outline drawings.

COURTS AND DOCTORS. By Lloyd Paul Stryker. New York, The Macmillan Company, 1932. $2.00.

This book is full of practical information and advice to practising physicians and surgeons, particularly in these days when suits for malpractice against the profession are so frequent. The average practitioner is so engrossed in the discharge of the obligation to his patients that, with very few exceptions, he pays no attention to the accessories and is quite unconscious of the legal danger around him.

The author of this book was for many years general counsel for the New York Medical Society and was requested by that Society to put into book form the results of his experience. He presents practical knowledge in regard to the relation of the physician to the public and to the law, with which every practising physician and surgeon should be familiar. The matter is put in simple and attractive language and should be read by members of the profession.

ARTÉRIOGRAPHIE DES MEMBRES ET DE L'AORTE ABDOMINALE. By Reynaldo Dos Santos, A. C. Lamas, et J. P. Caldas. Paris, Masson et Cie., 1931. 45 francs.

This book is in a way unique, for its authors have taken advantage of the methods recently developed which they have used to demonstrate the circulation of practically the entire body. With the increasing recognition of the evident importance of the character of circulation, especially with its derangement in all of the morbid processes, and of its influence on the healing of disordered tissue, the information contained on this subject will be appreciated. In the first portion of this book the author gives credit to the accomplishments of those who have already worked in the field. The technique used is also described. In the first portion are considered pathological conditions of the limbs,—including gangrene, ligatures and resection of arteries, aneurysms, osteomyelitis, and tumors. The second part is devoted to the study of the aorta,—including the iliac vessels, the abdominal viscera, and the pathological conditions of the kidney, spleen, and liver. The descriptions are accurate and the illustrations of the roentgenograms show clearly the circulation in all the affections described. Because of the scope which it covers, the book is of interest to the practitioner as well as to the specialist.

ORTHOPÄDISCHE THERAPIE IN DER ALLGEMEINPRAXIS (Orthopaedic Treatment in General Practice). Angeborene Deformitäten (Congenital Deformities). By Hofrat Prof. Dr. Hans Spitzy. Leipzig, Georg Thieme, 1931. 7 marks.

This new booklet on congenital deformities is not a section from one of Prof. Spitzy's previous works, but a thoroughly revised presentation of the subject in terms simple enough for a nurse. It is essentially a "one-man book", however, and not a summary of modern methods. As such it should be more valuable to orthopaedic surgeons than to general practitioners. Simple measures for the improvement of minor deformities are intended to be carried out by the family doctor. More complicated orthopaedic procedures are briefly outlined.

Many of the excellent illustrations are new and are supplied, for the most part, with generous legends. Amusing to an American reader is the presence of a pacifier in almost every infant mouth. The text is brief and easy to read with sufficient descriptive matter to supplement the illustrations.

A DOCTOR OF THE 1870'S AND 80'S. By William Allen Pusey. Springfield, Illinois, Charles C. Thomas, 1932. $3.00.

In this little book Dr. Pusey has given a simple and charming sketch of that fine type of man, the country practitioner, now not entirely disappearing, but certainly not often seen. The life of close human contact, working with limited facilities and under different conditions before the days of scientific research, developed in these men a keenness and accuracy of observation now too seldom seen. As the old-time country doctor disappears, we do not like to feel that this type of man is lost. Many times he has been transferred to the laboratory and to the purely scientific medical world and a different product is taking his place, in whom the human element is just as necessary but more difficult to maintain because of the loss of that human contact.

Dr. Pusey has shown in a simple way and with a breadth of understanding a knowledge of remarkable men. He has given to his readers the true story of the life of these men without resorting to fiction to develop interest. The life of this type of man is sufficient in itself.

L'OSTÉOSE PARATHYROIDIENNE ET LES OSTÉOPATHIES CHRONIQUES. By J.-A. Lièvre. Paris, Masson et Cie., 1932. 60 francs.

Although much has been written of late as to the parathyroid influence in the formation of cystic lesions of bone, there is still, in some quarters, hesitation about accepting too positive an opinion with reference to this relation. In the course of the development

of this subject, a somewhat confused classification and terminology has resulted. In this work, the author has rearranged the grouping according to a more practical method. He has thoroughly studied this subject from the various angles and has reported his results in a convincing manner. His initiative proceeded from his experience with two operated cases—two personal cases—the results of which gave encouragement. He reviews the history of these osseous lesions—from Stein in 1783—and also reviews cases of adenomectomies in the literature (eighteen in number), and discusses the relation of the parathyroid to the formation of this type of osseous lesion. He also has discussed, rather in detail, the relation of osteofibroma to osteomalacia and similar bone affections. After establishing his opinion in regard to the relation between this form of lesion and the parathyroid, he gives a chapter to the consideration of the objections which have been made to this theory and also some of the conditions which do not seem at first sight to endorse this opinion. The clinical picture, including the pathology and the differential diagnosis between the very slight or similar bone affections (nine in number), is discussed. The author considers that *l'ostéose parathyroidienne* is a distinct entity and has given clearly the reasons for his views. This treatise presents the subject up to date.

UNTERSUCHUNGEN ÜBER DAS WIRBELGLEITEN. By Prof. Hermann Meyer-Burgdorff, Oberarzt der Chirurgischen Univ.-Klinik, Rostock. Leipzig, Georg Thieme, 1931. 136 pages. 17 marks.

A very thorough presentation of this spinal condition, based on the study of pathology by anatomical and x-ray investigation, and applied to the clinical observations. The various anatomical affections and variations of this region, and the part which they play as potential factors, are described and illustrated and are interesting. The clinical influence of strains, fractures, and diseases, and their effect on the development of the pathological conditions, are given in the discussion of diagnosis. The book is fully illustrated (155 in number) by excellent reproductions of x-rays. A full bibliography is appended. The book is recommended for its clear presentation and discussion of the different phases of this affection which are of interest to surgeons.

SURGERY OF THE CHEST. By Dr. George F. Straub. Springfield, Illinois, Charles C. Thomas, 1932. $10.50.

In his "Surgery of the Chest", Dr. Straub has produced a valuable manual and practical guide for workers in this field. The book is notable for its remarkable compactness and wealth of information, and the abundance of excellent illustrations, many of which are sketches or diagrams by the author's hand.

In the introductory chapters, the author enters at once on the subject of pathological physiology which is clearly and concisely stated. The various forms of pneumothorax are explained by excellent illustrative diagrams. In considering diagnosis in general by physical examination and the use of x-rays, useful points are emphasized and helpful hints given.

A chapter on the preparation of the patient for operation, choice of anaesthetic, etc., contains practical points on the position of the patient on the operating table, conduct of anaesthesia and the use of positive pressure apparatus.

The subjects of thoracotomy and of the various operations on the lungs are well discussed, emphasis being on general principles rather than minute details. An interesting chapter on Injuries of the Thorax contains valuable points in diagnosis and treatment.

In the chapters on Pulmonary Tuberculosis, written in part with the collaboration of Dr. H. O. Arnold, the author has produced a particularly valuable piece of work on account of its completeness and sanity. Rules for selection of cases for pneumothorax, phrenicectomy and thoracoplastic operations, are well expressed. The importance of the cooperation of an expert internist, a radiologist and surgeon is emphasized. The

author cautions especially against the present day "operative furor", and advises strongly against partial procedure. In thoracoplasty, while believing a single stage procedure is ideal, he admits the necessity often of multistage operations and gives rules for deciding on these points. In tubercular cases his choice of anaesthetic is local and regional, supplemented, if necessary, by light nitrous oxid and oxygen.

His discussion of Pleurisy, Empyema (acute and chronic), and of Suppurative Diseases of the Lung, expresses the teaching and practice of most experienced surgeons of the present day. The discussion of Tumors of the Thorax and Mediastinum is necessarily brief, but the essentials of diagnosis and guiding principles of treatment are adequately stated. The same can be said of the chapters on Injuries of the Heart and Pericardium, Diseases of the Thoracic Esophagus, and Injuries and Herniae of the Diaphragm.

The work concludes with a chapter upon the Surgical Treatment of Angina Pectoris and Asthma, in which the present-day theories of etiology and methods of treatment are outlined. He expresses a wise personal conservatism in recommending alcohol block of the principal nerves concerned before resorting to more serious operations. Printed in clear type, and with many colored plates, the book is an attractive addition to surgical literature.

CONQUERING ARTHRITIS. By H. M. Margolis, M.D. New York, The Macmillan Company, 1931. $2.00.

The author of this book has evidently had a large experience with arthritic patients,—discouraged patients who have been confused by the various theories published, as well as what "is circulated of the disease through gossip and uncritical writers and quacks". The book is an honest attempt to clarify for the arthritic patient the present knowledge of the arthritides. The author devotes one chapter to the history of arthritic disease, and discusses in considerable detail the various types of chronic arthritis, giving special attention to infectious arthritis. The closing chapters are devoted to the treatment of chronic arthritis by the methods in general use. The place of orthopaedic surgery in the treatment of arthritis is briefly mentioned.

In spite of the evident purpose of the book, it is doubtful if many surgeons would consider it wise to recommend it to arthritic patients. Many doctors would not agree with the classification as chosen by the author: senescent arthritis, static arthritis, metabolic arthritis, and infectious arthritis. Some will also disagree with the statement "The diagnosis as well as the treatment can be adequately determined in most instances by the family physician". Undoubtedly, the book will appeal to certain patients as a summary of reliable information not easy for the layman to obtain. Although the author states repeatedly that the book "is not intended as a home guide for self-treatment by the patient", the title of the book may attract people who intend to use it as such.

DIE PSEUDARTHROSEN (NEBST WAHRSCHEINLICHEN VORSTADIEN) NACH MEDIALEN FRACTUREN DES COLLUM FEMORIS UND DEREN BEHANDLUNG [Pseudarthrosis (and Probable Preceding Stages) After Medial Fractures of the Femoral Neck, and their Treatment]. By H. Camitz. Acta Chirurgica Scandinavica, Vol. LXVIII, Supplementum XIX. Stockholm. Kungl. Boktryckeriet. P. A. Norstedt & Söner, 1931.

In a monograph of little more than one hundred pages of concise German is included a comprehensive discussion of anatomy, histology, statics, methods of treatment, and results. The management of disabling non-union receives the greatest emphasis. Such representative methods of treatment as brace or plaster immobilization, blood injection, transposition, suturing with wire, nailing, fixing with screws, bone pegging, and reconstruction operations are discussed and found wanting in a large proportion of cases. A series of end results from the literature are subjected to a critical survey. Dr. Camitz proposes a high subtrochanteric osteotomy as the logical procedure and defends it on mechanical and physiological grounds. In his excellent presentation one error should

not go unchallenged, however. The late Dr. A. Schanz of Dresden is credited with the *low* subtrochanteric osteotomy, such as he used in neglected congenital dislocations of the hip. In his textbook (page 327) Schanz states specifically that a *high* osteotomy should be done in medial fractures of the femoral neck. Camitz would treat all fresh medial fractures of the femoral neck as suggested by Whitman with emphasis on a meticulous plaster technique. In those which fail to unite in three months (occasionally less) where no contra-indication is present, he would perform a high subtrochanteric osteotomy immediately. Twelve cases are reported with clear x-ray reproductions.

The Journal wishes to acknowledge the receipt of the following publications sent to the Editorial Department:

Slovanský Sbornik Ortopedický. Brno, Czechoslovakia, Vol. VII, No. 1, 1932.

L'Enseignement Médical en France. Edited by La Presse Médicale. Paris, Masson et Cie., 1932.

Norsk Magasin for Laegevidenskapen. Oslo, Vol. XCII, Nos. 11 and 12, November and December, 1931; Vol. XCIII, Nos. 1, 2, and 3, January, February, and March, 1932.

Annual Report of the Division of Social Hygiene. New York State Department of Health. New York, 1931.

Ortopedia e Traumatologia dell' Apparato Motore. Rome, Vol. III, Fasc. 5 and 6, October and December, 1931.

FURTHER OBSERVATIONS ON OSTEITIS FIBROSA GENERALISATA. E. Ask-Upmark. *Acta Chir. Scandinavica*, LXVIII, 551. 1931.

A female, forty-three years old, suffered for thirteen years with a disease which had been diagnosed as Paget's. With conservative treatment for the last six years there was increased weakness, generalized pain, and bony deformity. The stature became less from vertebral involvement and the head enlarged. Early thickening and increased density of the cortex of the long bones and of the skull were later changed to extreme patchy rarefaction and cyst formation with grotesque deformity. The blood calcium was fourteen and four-tenths milligrams per 100 cubic centimeters. The diagnosis was changed to Recklinghausen's multiple osteitis fibrosa, and the parathyroids explored. Two normal glands and an adenoma were removed. On the fourth day the patient became irritable and displayed violent fits of activity. There was no actual tetany, but the Chvostek sign became positive. The blood calcium fell to about five milligrams in spite of calcium, parathormone, and other therapy, and on the eleventh day the patient died. Interesting were the autopsy findings of calcium deposits in the kidneys, and complete (too extensive) removal of parathyroid tissue. The literature is discussed. Vitamin-rich substances, ultra-violet light, parathormone, thyroid extract, and calcium chlorid are valuable therapeutic measures in conjunction with parathyroidectomy.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

ON INJURIES TO THE CRUCIAL LIGAMENTS OF THE KNEE-JOINT. Ivar Palmer. *Acta Chir. Scandinavica*, LXIX, 43, 1931.

A study of the mechanism of crucial ligament injury is followed by the presentation of two cases. One was a posterior and one an anterior ligament. The "drawer sign" (abnormal anteroposterior mobility) was positive posteriorly and anteriorly respectively. The injured anterior ligament was only partially torn and was successfully sutured. The ruptured posterior ligament was treated conservatively with persistence of symptoms. The writer suggests a method of surgical repair of the posterior crucial which he has worked out on the cadaver.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

Beitrag zur Kenntnis des Allgemeinen Vorkommens des Hämangioms in de Wirbelsäule (A Contribution on the General Occurrence of Hemangiomata the Spine). C. Sandahl. *Acta Chir. Scandinavica*, LXIX, 63, 1931.

The discovery of an hemangioma of the twelfth thoracic vertebra in a girl of seven teen years prompted the writer to review the literature and tabulate fifteen cases vertebral hemangioma with compression of the cord. Neurologic symptoms occur a a result of angulation of spine, enlargement of the neural arch, or development of a epidural angioma. In none of the tabulated cases was an exact roentgenologic diagnosi made, although the x-ray appearance is characteristic. The vertebral body casts striped or coarse-meshed shadow with fewer and coarser trabeculae which give it sponge-like appearance. Complete replacement of the vertebral body by the tumo leads to compression and broadening. Reproductions of the writer's and other x-ray are included.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

Kann eine Während der Geburt bei dem Kinde Enstandene Gasemolie die Ursache der Angeborenen, Spastischen Diplegie oder Littleschen Krankheit Sein? (Can Gas Embolism in the Child at Birth Be the Cause of Congenital Spastic Diplegia or Little's Disease?) F. Langenskiöld. *Acta Orthop. Scandinavica*, II, 137, 1931.

After reviewing the theories of causation of true congenital diplegia—asphyxia, trauma, developmental arrest, degeneration, and primary defect—the writer proposes gas embolism as a likely cause. The clinical similarity between caisson disease and Little's disease suggested the possibility. Gas emboli have been found in the brains of men dying of caisson disease. Air in the heart and large vessels has been reported at autopsy of the asphyxiated new-born by several writers. Intra-uterine pressure can exceed 400 millimeters of mercury during labor pains. It is possible that, with this pressure, air accidentally introduced into the cavity could be forced through the placental veins. By passing through Botalli's duct the gas would soon reach the arterioles of the brain. Diapedesis of compressed air into the alveolar vessels seems less likely. Rabbit experiments were rather unsuccessful. In addition to congenital diplegia, the writer suggests that congenital nystagmus, athetosis, and deaf mutism may be explained on the basis of air embolism at parturition.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

Two Cases of Ganglion in the Sheath of the Peroneal Nerve. Torsten Wadstein. *Acta Orthop. Scandinavica*, II, 221, 1931.

In two cases paralysis of the peroneal nerve was associated with cyst-like degeneration of the nerve sheath. In one case gelatinous fluid was accumulated in one cyst with no history of trauma; in the other, there was a preceding injury and the lesions were multiple. Surgical removal of the ganglia resulted in almost complete return of function in the case of the single lesion and in relief of pain with the multiple.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

Significance of the Retention Ratio of Calcium: Phosphorus in Infants and in Children. G. Stearns. *Am. J. Dis. Child.*, XLII, 749, Oct. 1931.

In the study of calcium and phosphorous metabolism, the relation of these elements is as important as their amount. Their retention indicates the comparative rates of growth of soft and bony tissues, since ninety-seven to ninety-eight per cent. of retained calcium is utilized in bone formation and phosphorous in bone and soft-tissue formation.

A retention ratio between 1.5 : 1 and 2 : 1 is considered normal for an infant up to one year of age. Ratios below 1.5 : 1 indicate a more rapid growth of soft tissue than of bone, while ratios above 2 : 1 are probably indicative that a calcium shortage is being corrected.

For artificially fed infants, a retention of at least forty milligrams of calcium and from twenty to twenty-five milligrams of phosphorous per kilogram of body weight per day is considered desirable.

In older children, the ratio is somewhat lower, because of the great increase in muscular tissue,—usually about 1 : 1 or slightly above. All children should retain

at least ten milligrams of calcium and of phosphorous per kilogram of body weight per day for optimal growth and well-being.—*W. Hamsa, M.D., Iowa City, Iowa.*

MULTIPLE MANIFESTATIONS OF SUBCHONDRAL NECROSIS (Osteochondropathia Juvenilis, Osteochondritis, Epiphysitis). W. C. Martin, and Hugo Roesler. *Am. J. Roentgenol.*, XXVI, 861, Dec. 1931.

For the last thirty years an increasing number of disease entities affecting the skeleton of young, growing individuals have been described; they follow a benign course and tend to heal without treatment. Skiagraphic examinations of these lesions in different bones show great similarities; one finds early primary necrosis; later this may be followed by pulverization of the trabeculae associated with hemorrhages: sometimes compression fractures.

This paper is very well illustrated with roentgenograms of these conditions in different bones and a summary of one case with a detailed follow-up examination. This case presents a multiplicity of lesions limited to the subchondral bone. Etiology is still unknown. The author advises palliative measures until the disease becomes stationary. —*Edward S. Hatch, M.D., New Orleans, Louisiana.*

AN UNUSUAL MANIFESTATION OF EPIPHYSEAL AND JOINT PATHOLOGY IN A NEW-BORN INFANT. Milton J. Geyman. *Am. J. Roentgenol.*, XXVI, 868, Dec. 1931.

A case is reported in which there was marked abnormal roentgen findings in a child aged two months. This baby was sent for examination because of apparent shortness of the left lower extremity. The child was of full term and normal delivery. Family history negative. Skiagraphic findings consisted of multiple small bony bodies scattered about the region of the joints. On the left ankle there was a ragged os calcis and numerous osseous nuclei, also multiple osseous nuclei in the region of the left knee joint. Most probable etiology—chondrodystrophy. The lack of periosteal changes and particularly the clean-cut appearance of the diaphyses would appear to rule against even an atypical syphilis.—*Edward S. Hatch, M.D., New Orleans, Louisiana.*

INCISION FOR EXPOSURE OF THE ELBOW JOINT. W. C. Campbell. *Am. J. Surg.*, XV, 65, Jan. 1932.

The difficulty of devising a surgical procedure to fully explore the elbow joint has long been recognized and Campbell and Malesworth of England have independently worked out the problem by the same method,—a medial incision over the tip of the internal condyle and the ulnar nerve retracted, the epicondyle and the attached flexor muscles chiselled loose and retracted, blunt dissection to the capsule and periosteum of the humerus as needed so the joint can be opened outward, exposing the whole joint. This incision should prove useful and practical.—*Custis Lee Hall, M.D., Washington, D. C.*

NEW BONE LENGTHENING APPARATUS FOR THE FEMUR. G. K. Coonse. *Am. J. Surg.*, XV, 68, Jan. 1932.

The author uses the femur by preference instead of the lower leg for bone lengthening procedures in this preliminary report. He uses four Steinmann pins, two above and two below the osteotomy, and rigid side bars gradually lengthening the leg at the rate of one-eighth of an inch daily until the desired length is obtained. The apparatus is stated to be so rigid that plaster is not needed and control of the fragments is easy. Further reports should prove interesting.—*Custis Lee Hall, M.D., Washington, D. C.*

INTRA-ARTICULAR STABILIZATION FOR RECURRING DISLOCATION OF THE SHOULDER. C. M. Gratz and R. P. Robison. *Am. J. Surg.*, XV, 71, Jan. 1932.

The authors use a strip of fascia lata as an intra-articular suture through the head of the humerus to the upper posterior portion of the glenoid and fastened to the glenoid. The method is claimed to give firm stabilization of the joint, greater suture viability, maximum mobility of the shoulder, and natural compensation for correction of the deformity. Also discussed are the viability of the autogenous suture and methods of

fixation. One case report is included and further case reports would aid in determining results for a comparison with other methods, including that of Nicola, which seems to be the most satisfactory method to date. *Custis Lee Hall, M.D., Washington, D. C.*

THE OPERATIVE CURE OF HALLUX VALGUS AND BUNIONS. Samuel Kleinberg. *Am. J. Surg.*, XV, 75, Jan. 1932.

After a review of the types of current corrective procedures and a discussion of the pathological anatomy and the mechanism of production of the deformity, the author discusses an operation designed to correct all the elements of the deformity and yet maintain function of the foot to the utmost. A double wedge resection at the tarsometatarsal joint is used, with alignment of the first metatarsal shaft parallel with the other metatarsals, thus correcting the adduction. The enlargement of the first metatarsal head is removed and filed smooth, and a tongue of bursa and capsule is sutured to the inner aspect of the metatarsal bone. Eight cases are mentioned, two in detail. The operation is well worked out mechanically and has obvious advantages to recommend its use in suitable cases. —*Custis Lee Hall, M.D., Washington, D. C.*

OSTEOMYELITIS OF THE VERTEBRAE WITH A REPORT OF TWO CASES SIMULATING PERINEPHRITIC ABSCESS. J. A. Lazarus. *Am. J. Surg.*, XV, 82, Jan. 1932.

This comparatively rare complication of infection of the vertebrae is well discussed from the standpoint of incidence, symptomatology, pathology, and treatment, and the points brought out by two detailed case reports which suggested perirenal or kidney disease. The x-ray seems of little aid in making the diagnosis. The operative procedure should consist of liberating the pus and gently curetting the involved bone.—*Custis Lee Hall, M.D., Washington, D. C.*

THE RÖNTGENOGRAPHIC VISUALIZATION OF THE ARTERIES OF THE EXTREMITIES IN PERIPHERAL VASCULAR DISEASE. H. E. Pearse, Jr., and S. L. Warren. *Ann. Surg.*, XCIV, 1094, Dec. 1931.

Sodium-monoiodo-methane sulphonate (methiodol), twenty grams in a forty per cent. solution, is used in arteriography. A dose of forty grams is safe, given intravenously; a forty per cent. solution is sufficiently radio-opaque and was found to have no deleterious action on the vessel walls. *Technique:* No tourniquet is used. The femoral artery is exposed in Hunter's canal under spinal anaesthesia and separated from the femoral vein and nerve. It is compressed between the thumb and finger, punctured with a sharp twenty-gauge needle, to which is attached a fifty cubic-centimeter syringe containing the methiodol solution. The film, which was initially placed under while the roentgen tube was centered over the area to be studied, is exposed after twenty-five cubic centimeters have been injected and the fluid is still being forced into the artery. The injection is stopped, the film changed, and after injecting an additional twenty-five cubic centimeters, an exposure is made while the last five cubic centimeters of the solution is being injected into the vessel.

After withdrawal of the needle, the pressure on the artery is released; a moment's pressure with a sponge stops all bleeding. Ninety seconds or less is required to complete the injection.

Seven case histories are reported, and there are six illustrations showing roentgenographic results.—*N. T. Kirk, M.D., Washington, D. C.*

GANGRENE OF THE FINGER FOLLOWING DIGITAL NERVE BLOCK ANAESTHESIA. J. H. Garlock. *Ann. Surg.*, XCIV, 1103, Dec. 1931.

Four cases of dry gangrene of the finger following digital nerve block anaesthesia, using five-tenths to one per cent. novocain, are reported. In each case a tight rubber band or catheter was used as a tourniquet about the base of the digit.

The author believes the essential factor to be a thrombosis of the digital vessels, produced by the tight application of a narrow tourniquet, supplemented by the increased

tissue pressure of the infiltrated anaesthetic agent. Infection was not a causative factor. He condemns a narrow tourniquet, states occlusion of the arterial supply is ordinarily contra-indicated, and recommends the Esmarch bandage when a bloodless field is desired.—*N. T. Kirk, M.D., Washington, D. C.*

HEMIPELVECTOMY. Kellogg Speed. *Ann. Surg.*, XCV, 167, 1932.

Indications: (1) Disease (tumors, malignant or benign) of bone or soft tissues of the proximal thigh where hip-joint disarticulation will not suffice.

(2) Malignancy of ilium or soft-tissue covering, extending into the thigh.

(3) Dissecting aneurysms of femoral artery.

(4) Crushing injuries of the hip region with gas infections. Metastasis in malignancy is a contra-indication and local extension beyond the sacro-iliac or symphysis pubis joints on into the pelvic floor. The patient should be a reasonable surgical risk and willing to take the chance of loss of life.

Technique: The incision extends from a short distance in front of the posterior superior spine, along the crest of the ilium, past the anterior superior spine, along the superior pubic ramus to the symphysis so as not to endanger the spermatic cord. The incision is deepened to bone, abdominal muscles are cut free, and the iliacus muscle exposed by pushing back the reflected abdominal wall and peritoneum. The superficial and inferior epigastric and circumflex iliac vessels are clamped and ligated, and the iliacus muscle is freed and reflected. The dissection passes forward; the great vessels are clamped and ligated as they cross the pubic spine.

The spermatic cord is retracted, the dissection hugs the pubic ramus and the symphysis is cut through with a knife. The pelvis is sprung outward, the incisions being directed downward and backward, avoiding the scrotum and anus, to curve around the thigh below the gluteal crease. The inferior ramus is exposed by cutting the thigh adductors at their origin to the pubes. The psoas and iliacus muscles are severed between clamps.

The operator returns to the original site, extends the incision along the sacro-iliac joint, curving down the buttock to meet the anterior incision. The sacro-iliac joint is sectioned, the dissection is carried through the gluteal mass of muscles; the ischial tuberosity and rami are dissected out, and the sciatic nerve is injected and cut high. Bleeding vessels are clamped as cut. The half pelvis and attached leg are thus removed. All vessels are ligated, all pathological tissue is removed, and the gluteal flap is then turned upward and sutured to the abdominal muscles and fascia. The skin is closed and the wound drained.

Two cases are reported, the indications for amputation in both being malignancy. Both patients died of shock, the first on the operating table, the second within two hours of the operation.—*N. T. Kirk, M.D., Washington, D. C.*

HEMOPHILIC ARTHRITIS (Bleeder's Joints). J. Albert Key. *Ann. Surg.*, XCV, 198, 1932.

A case report is made with operative findings, in which a fatality was narrowly averted and the clinical picture and pathology of hemophilic arthritis is described.

Volkmann is credited with first differentiating the condition in 1868; König in 1892 divided the condition into three stages—(1) hemarthrosis, (2) panarthritis, and (3) regressive stage, and warned against operation under a mistaken diagnosis.

Pathology

Soft tissues—Hemorrhage into the joint results from injury or otherwise, the joint becoming distended with non-clotting blood under pressure, causing a mechanical disability and acting as an irritant, resulting in a hyperplasia of the synovial membrane.

An accumulation of phagocyting macrophages occurs in the subsynovial tissues where they die, releasing the blood pigment from phagocytized red blood cells. With each new hemorrhage this process is repeated; the synovial membrane hypertrophies with formation of folds and villi. The area around the joint becomes saturated with blood pigment and a dense layer of fibrous connective tissue forms in the subsynovial

layer, decreasing the size of and motion in the joint, tending to produce a fibrous ankylosis. If the tendency to bleeding ceases, the synovial membrane tends to return to normal.

Cartilage—Cartilage changes come late. Erosion occurs around its margins due to encroachment of the hyperplastic synovial membrane and a variable amount of spotty destruction over its articular surface occurs, preceded by cartilage-cell death, with fibrosis and degeneration of matrix. This destruction is irregular in contour; is map-like in character, not at the points of pressure in the joint; and is characteristic of the disease. The underlying bone is covered with a layer of connective tissue or may present a depression or cavitation filled with an organized hematoma. Bony ankylosis does not occur.

Bone—The characteristic feature is cavitation in the intra-articular portion, in the articular surface, or deep in the cancellous bone. Freund, Reineke, and Wohlwill believe this due to intra-articular pressure, as in aneurysm, and that hemophilic blood has an unknown chemical effect. The author believes it due to intra-osseous hemorrhage in the atrophic bone, followed by aseptic necrosis and absorption. These areas of bone destruction can frequently be visualized by x-ray, and when present are characteristic of advanced hemophilic arthritis. Marginal osteophytes or exostoses occur rarely. The joint may simulate hypertrophic arthritis if the patient grows old and bleeding ceases. Marked deformity occurs as the disease progresses and the x-ray and clinical findings may simulate any kind of arthritis.

Clinical picture

This varies with the stage of the disease. The author recognizes two stages of the disease—(1) *Acute hemarthrosis:* The joint disturbance in hemophilia nearly always begins in childhood and may be seen by the surgeon in the first attack, or there may be history of previous attacks in that or other joints with a disappearance of symptoms with rest and a return of the joint to normal or the development of a chronic arthritis. The hemarthrosis may have occurred while the child slept, but in most instances followed a minor injury or strain. The effusion may occur slowly or rapidly, may be slight in amount or extreme, and under considerable pressure. Pain and loss of function tends to be slight or severe, varying directly with the amount of effusion and pressure. There is accompanying muscle spasm; the superficial joint may be definitely blue (cyanotic) in color with no increase in local heat or redness. The temperature is slightly elevated and there is usually a moderate leukocytosis. (2) *Chronic arthritic stage:* This is the stage in which the joint fails to return to an apparently normal condition after the hemorrhage. It may follow the first attack, but usually joint changes do not occur until after several attacks. The joint remains swollen, tender, sore, and painful for several weeks or months; the arthritis progresses; repeated attacks of acute pain and swelling occur with increase of permanent disturbance of function. This tends to be progressive; contractures, deformity, periarticular thickening, and muscle atrophy develop and increase after each fresh hemorrhage. The blood-clotting time tends to be prolonged to a variable degree.

Treatment

Acute hemarthrosis:—Rest in bed with immobilization of joint by splint or plaster-of-Paris. Aspiration may be dangerous. Function may be resumed when the swelling and pain subsides, and future trauma avoided.

Chronic arthritis:—(1) Correction of deformities when incapacitating by non-operative conservative means, *i.e.*, traction, wedging plaster casts or other mechanical splints, and maintenance of corrected position sufficient to prevent recurrence. (2) Support of involved joints, usually only indicated during an acute attack; elastic bandage may afford comfort.

Severe hemorrhage is combated by reducing coagulation tissue and restoring blood lost, by transfusion of whole blood.

The author was able to increase the number of blood platelets in his case by the use of irradiated ergosterol.—*N. T. Kirk, M.D., Washington, D. C.*

Bacteriologic Investigations on the Blood, Synovial Fluid and Subcutaneous Nodules in Rheumatoid (Chronic Infectious) Arthritis. Martin H. Dawson, Miriam Olmstead, and Ralph H. Boots. *Arch. Int. Med.*, XLIX, 173, Feb. 1932.

Blood cultures were taken upon eighty patients suffering from rheumatoid arthritis (chronic infectious and atrophic arthritis) employing the technique of Cecil, Nicholls, and Stainsby. Of 204 samples of blood, twenty-eight per cent. yielded a growth of a variety of organisms which were not regarded as of etiological significance. In fifteen control subjects, of thirty-one samples of blood, thirteen per cent. yielded growth. Twenty-five per cent. of sixteen samples of sterile agar subjected to similar manipulation yielded growth. These results seem to the authors to call into serious question the significance of any bacterial growth encountered when this involved technique is used.

Aerobic and anaerobic cultures of twenty-three specimens of synovial fluid, and of twelve subcutaneous nodules, failed to yield organisms that could be considered of etiological significance.—*Clark W. Heath, M.D., Boston, Mass.*

Chronic Arthritis. With Special Reference to Intravenous Vaccine Therapy. MacNider Wetherby and B. J. Clawson. *Arch. Int. Med.*, XLIX, 303, Feb. 1932.

The authors found clinical improvement in seventy-five per cent. of 100 cases of various forms of chronic arthritis, following a course of intravenous injections of a killed streptococcus viridans strain of organism. Further observations over a long period of time are necessary to demonstrate whether this improvement is permanent. The rationale of the procedure is explained by the probable infectious origin of chronic arthritis (the authors found twenty-five of fifty blood cultures in chronic arthritis positive for streptococcus), and by the tendency of the patients to become desensitized, as indicated by a positive skin test becoming negative and by a marked increase of the streptococcic agglutinins in the serum following intravenous vaccination.—*Clark W. Heath, M.D., Boston, Mass.*

Altersveränderungen der Menschlichen Wirbelsäule (mit Besonderer Berücksichtigung der Röntgenbefunde). II. **Die Alterskyphose.** (Senile Changes in the Human Spine. II. Senile Kyphosis). H. Junghanns. *Arch. f. Klin. Chir.*, CLXVI, 106, 1931.

Typical senile kyphosis arises as a result of degenerative changes of the anterior portion of the intervertebral disc near the vertebral body epiphysis. The first change consists of concentric tears of the intervertebral disc or a complete necrosis of the anterior portion of the disc. This produces a diminution of the intervertebral space anteriorly, abnormal movements and friction, and thereby a sclerosis of the spongiosa in the adjacent vertebral bodies. In addition to this, marginal spurs are formed along the anterior edges of the vertebral bodies. Then follows a gradual ingrowth of fibrous tissue and later spongy bone into the necrotic portion of the disc, thus leading to a complete ankylosis of the affected spinal segments. The middle and the posterior portions of the disc are not affected in this process.

The kyphosis is formed by a decrease in height of the anterior part of the intervertebral space due to the necrosis and ossification. This usually occurs in several successive discs after which the process continues downward. The height of the kyphosis is in the mid-thoracic region.

Senile kyphosis is not related to the kyphosis of adolescence, Bechterew's disease, or spondylosis deformans. It is a senile change brought about by a decrease in muscle power and loss of elasticity of ligaments of the spine, thus causing abnormal pressure on the anterior portion of the intervertebral disc.—*R. J. Dittrich, M.D., Wichita, Kansas.*

ALTERSVERÄNDERUNGEN DER MENSCHLICHEN WIRBELSÄULE (mit Besonderer Berücksichtigung der Röntgenbefunde). III. HÄUFIGKEIT UND ANATOMISCHES BILD DER SPONDYLOSIS DEFORMANS. (Senile Changes in the Human Spine. III. Incidence and Anatomical Aspects of Spondylosis Deformans.) H. Junghanns. *Arch. f. Klin. Chir.*, CLXVI, 120, 1931.

The author made a study of 4253 human spines at autopsy in which the marginal bone changes of the thoracic and lumbar vertebrae were closely examined. From this it was determined, in contrast to statements from clinical studies, that spondylosis deformans occurs with equal frequency in men and in women.

At fifty years of age practically eighty per cent. of the men and fully sixty per cent. of the women show marginal bone changes, and after the age of seventy, more than ninety per cent. of all people have spondylosis deformans.

The marginal spurs and lipping in spondyloses arise on the outer surfaces of the vertebral body at a point at which during youth the actual vertebral body unites with the vertebral body epiphysis, therefore somewhat below the upper border of the adult vertebra. This is also the point at which the anterior longitudinal ligament arises from the vertebra. The bony outgrowth then projects over the margin of the vertebra, the intervertebral disc, and the margin of the adjacent vertebra to make a contact with the outer surface of the latter.

The cause of marginal osteophytes is a degenerative change of the intervertebral disc, which produces an abnormal mobility of the spine and thereby an abnormal pull on the anterior ligaments. In the vertebral canal bony growths cannot be formed in this manner, as the posterior ligaments arise, not from the vertebrae, but from the intervertebral discs. Cartilaginous and bony outgrowths in this area must be considered as tissue of the disc, altered in some manner and prolapsed posteriorly.

Spondylitis ankylopoetica (Strümpell-Marie-Bechterew) can be definitely separated from spondylosis deformans, at least in its final condition, as it is characterized by a complete ossification of the small joints of the vertebrae and a smooth ossification of the anterior ligaments, without marginal spurs or osteophytes.

The question regarding the relationship between trauma and spondylosis cannot be answered with certainty, from the anatomical investigations.—*R. J. Dittrich, M.D., Wichita, Kansas.*

ZUR STATISTIK DER SPONDYLITIS TUBERCULOSA. (Statistical Study of Tuberculous Spondylitis.) H. Kuss. *Arch. f. Klin. Chir.*, CLXVI, 136, 1931.

From a statistical analysis of 250 cases of tuberculous spondylitis observed during a period of eight years (1922–1929) the following summary is made: Spondylitis constitutes thirteen and six-tenths per cent. of all cases of tuberculous disease of bones and joints. It is most common during the third decade of life. Men are not more frequently affected than women. Occupations involving heavy physical labor do not predispose to this disease. The twelfth thoracic and the third lumbar vertebrae are most frequently affected. Abscesses occurred in forty-two per cent. The average duration of fistulous discharge from abscesses was four and three-tenths years. Abscesses were formed slightly more often on the right side of the body. The most common localization of abscesses was in the psoas muscle. Paralyses were found in two per cent. of the cases. In thirty-nine and six-tenths per cent. of the cases spondylitis was preceded by tuberculous disease elsewhere; in fifteen and two-tenths per cent. it was followed by other forms. The average duration of the disease was five and three-tenths years. The mortality was fourteen per cent.—*R. J. Dittrich, M.D., Wichita, Kansas.*

COXA VARA EPIPHYSAREA. VERLAUF, BEHANDLUNG, ENDAUSGÄNGE, ÄTIOLOGIE. (Coxa Vara Epiphysarea; Course, Treatment, End Results, Etiology.) H. Friedrich. *Arch. f. Klin. Chir.*, CLXVIII, 132, 1932.

The author has made an analysis of thirteen cases of coxa vara of which all had been observed for at least six years, and the majority for periods of ten to fifteen years.

In addition, fifteen more recent cases were studied with regard to etiology and findings in the early stages.

Among the patients of the first group, all had serious disability and eight had a complete ankylosis of the hip. None of the patients had had sufficient treatment, according to present conceptions. Owing to economic conditions, some had to discontinue treatment, while others had no treatment whatever.

In spite of the lack of adequate treatment, the results at the time of reexamination were surprisingly good. None of the hips were ankylosed. The most unfavorable case, functionally, was one in which the hip could be flexed fifty degrees and rotated to one-third of its normal range. All patients were able to work. Four were free from symptoms, and eight had mild symptoms periodically. A remarkable feature was the absence of any further displacement of the epiphysis, in spite of lack of after-treatment.

Treatment consists of immobilization with a brace or cast designed to eliminate weight-bearing. The apparatus is worn for three months. In painful cases, this is preceded by traction for several weeks.—*R. J. Dittrich, M.D., Wichita, Kansas.*

Sulla Correzione delle Contratture e delle Sublussazioni del Ginocchio da Arthosinovite Tubercolare. (On the Correction of Contractures and Subluxations of the Knee from Tuberculous Arthrosynovitis.) Francesco Satta. *Arch. di Ortop.*, XLVII, 689, Sept. 1931.

The author reviews briefly the general principles concerned in the prevention and treatment of contractures and dislocations about the knee joint. Usually slow correction with continuous traction is safest and most successful. Only rarely in very severe cases is operative correction necessary.

Satta describes and illustrates the varied types of extension he has used which do not interfere with the simultaneous employment of heliotherapy, which, he believes, is the most important factor in the healing process. Excellent results are reported.—
A. Louis Rosi, M.D., Chicago, Illinois.

Fratture del Carpo. (Fractures of the Carpus.) Rinaldo Micotti. *Arch. di Ortop.*, XLVII, 723, Sept. 1931.

Micotti presents a rather brief review of this subject and reports some typical cases. A short discussion of the normal position and movements of the carpal bones facilitates the understanding of the pathogenesis of their fractures.

Fractures of the os naviculare represent fifty-five to seventy per cent. of all carpal bone fractures. Only rarely are they the result of direct trauma, usually being due to some indirect force, such as a fall on the palm of the hand. In this position the bone is crushed between the radius and the os capitatum. The fracture may be intra- or extra-articular and involve the body or tuberosities. The diagnosis is not always possible without the aid of the roentgen ray. The prognosis should always be guarded because of the frequency of psuedarthrosis and arthritis. The author has had success with the non-operative treatment, consisting of two weeks' immobilization followed by gradual active and passive motion.

Fractures of the os lunatum constitute about eight per cent. of carpal bone fractures. The pathogenesis, diagnosis, and treatment are similar to those in fractures of the navicular.

The other bones are more rarely fractured and the diagnosis is usually made with the roentgen ray. Non-operative treatment is usually successful and was employed in all the reported cases. In comminuted fractures excision may be indicated.—*Peter A. Rosi, M.D., Chicago, Illinois.*

FRATTURA DI SHEPHERD ED OS TRIGONUM. (Fracture of Shepherd and Os Trigonum.) Gino Bettazzi. *Arch. di Ortop.*, XLVII, 767, Sept. 1931.

Fracture of the processus posterior tali (Shepherd's fracture) is rare and may be confused with the presence of the accessory os trigonum. The author reports a case and reviews the literature.

In a review of roentgenograms of 500 feet the author found seven probable cases of os trigonum. A definite diagnosis is not always possible. He also found this bone many times in the examination of cadavera, but less frequently than the literature would indicate.

Bettazzi was able to reproduce the fracture experimentally in seventy-five to eighty per cent. of his attempts on cadavera, by forcibly striking the heel of the hyperextended foot. The fracture probably occurs by a sheering or crushing mechanism.

The non-operative treatment usually is successful. Only rarely is excision indicated, the indications being long-continued pain and failure of callus formation. One must remember that this pain may be due to trauma to the tendons or peritendinous structures, which is not relieved by operation on the bone.—*A. Louis Rosi, M.D., Chicago, Illinois.*

THE RÔLE OF THE ANTERIOR LOBE OF THE PITUITARY GLAND IN GROWTH, WITH SPECIAL REFERENCE TO THE TEETH AND MAXILLAE. Wm. G. Downs, Jr. *Arch. Path.*, XII, 37, July 1931.

Working with small rodents and injecting them with Evan's alkaline anterior lobe extract, he found that:

1. There is in the substance of the anterior lobe something which affects general growth, through maintenance of the water content of the tissues and reducing the tendency to put on fat.

2. The effect on dentition is to accelerate this process and to change the position of the teeth in the jaws, owing to a difference in the size of the jaws. The dental acceleration is only a part of the general phenomena of body growth and may be influenced by the pituitary in a specific direction only in so far as the time and velocity of development of the various tissues and organs may be influenced.—*J. Kulowski, M. D., Iowa City, Iowa.*

THE SITES OF DECALCIFICATION AND OF BONE LESIONS IN EXPERIMENTAL HYPERPARATHYROIDISM. H. L. Jaffe, A. Bodansky, and J. E. Blair. *Arch. Path.*, XII, 715, Nov. 1931.

Many recent clinical and chemical studies have demonstrated the marked ease with which the mineral constituents of the bony skeleton are mobilized and depleted in a variety of conditions.

By experimental hyperparathyroidism upon guinea pigs, the authors show that the rate of decalcification at any site is related to the rate of bone growth and metabolic changes at that site.

They summarize the embryogenesis and post-natal development of the skeleton and emphasize the fact that bone formation and growth proceed at different rates in the various bones and even in various portions of the same bone. In the metaphyses of the long tubular bones, the costochondral junctions, the jaw, and the vicinity of the sutures of the skull bones, very active formation of bone goes on for a long time.

Experimentally, they prove that decalcification occurs in certain sites of predilection which are the metaphyseal regions in the long bones and at other regions of rapid growth. It follows then that the younger animals are more susceptible to decalcification. Bones, the sites of early complete ossification, do not exhibit the characteristic reaction.

This work disproves the recent work of Aub and his coworkers who state that the spongy bone in general is the available storehouse of calcium and that the cortical bone is called upon only in case of unusual body demands.

The writers' experiments were done on sixteen guinea pigs in groups, receiving increasing doses of parathyroid extract, followed by microscopic examination of the bones after death from hyperparathyroidism.

(This article is clearly comprehensible, well illustrated, and convincing. It proves, as do many observations, the tenability of Murk Jansen's "vulnerability of rapidly growing cells". This same principle sheds some light also on the incidence of the so called osteochondritides, tuberculosis, and pyogenic conditions in the regions of rapid growth in children.—Abstractor's note).—*J. Kulowski, M.D., Iowa City, Iowa.*

FRACTURES OF THE FEMUR. Treatment by the Russell Method of Traction: Report of Twenty-one Cases. Henry J. Lund. *Arch. Surg.*, XXIII, 889, Dec. 1931.

Twenty-one cases of fracture of the femur are described, treated by the Russell method of traction. The method of application of this type of traction is given and the *modus operandi* discussed. Essentially it is skin traction applied below the knee and depends for its effectiveness on a natural and comfortable position of the limb with a minimum of weight, whereby the equilibrium of the muscle is restored; with this restoration of muscle tone and position, the fractured ends of the bone fall into a more or less natural alignment, provided there is no interposed tissue.

From a study of his results the author concludes:

(1) Russell traction is the method of choice in treating all types of fracture of the femur, from the intertrochanteric to the lower epiphyseal region.

(2) It gives satisfactory position and alignment in all cases, except where muscle is interposed between the fractured ends. In only two cases of the series was open reduction necessary because of non-union and this was found to be due to interposed tissue.

(3) It gives a minimum of permanent changes in the joints.

(4) The average period of traction is nine weeks, of hospitalization, twelve weeks, and of temporary disability, nine months.

(5) The method is inexpensive, easy to apply, comfortable to the patient, and materially simplifies nursing care.—*I. William Nachlas, M.D., Baltimore, Md.*

PAGET'S DISEASE. A Predisposing Factor to Osteogenic Sarcoma. Bradley L. Coley and George S. Sharp. *Arch. Surg.*, XXIII, 918, Dec. 1931.

The authors discuss the frequent association of Paget's disease and osteogenic sarcoma in patients over fifty years of age. The theories of the etiology, pathology, and diagnosis of Paget's disease are presented. Seventy-one cases, twenty from the Memorial Hospital and fifty-one from the Bone Sarcoma Registry, are analyzed. These comprise cases of osteogenic sarcoma in patients over fifty years of age. The conclusions drawn from this study are as follows:—

(1) Paget's disease was found to be a predisposing factor to osteogenic sarcoma in twenty-eight per cent. of the seventy-one cases of osteogenic sarcoma in patients over fifty.

(2) Of patients with the two diseases associated, men are affected five times more frequently than women.

(3) Osteogenic sarcoma in patients over fifty has the same sites of predilection as in younger persons.

(4) When osteogenic sarcoma is associated with Paget's disease, it occurs in a bone showing the characteristic changes of Paget's disease.

(5) Paget's disease is present ten to fifteen years before the sarcoma develops.

(6) No record has been found of the survival for five years of a patient having the two diseases, regardless of the method of treatment.

(7) Preliminary radiation by intensive exposure to radium pack and x-ray, and amputation where possible, followed by the use of prophylactic constitutional therapy with the mixed toxins, are suggested as a method of treatment worthy of trial.—*I. William Nachlas, M.D., Baltimore, Md.*

THE ROENTGENOLOGIC DISPLACEMENTS IN COLLES' FRACTURE. With Special Reference to the Mechanism of the Accompanying Fracture of the Ulnar Styloid. A Report of One Hundred Consecutive Cases. Louis Carp. *Arch. Surg.*, XXIV, 1, Jan. 1932.

Based on a study of 100 consecutive cases, Carp reports the roentgenologic displacements and the mechanism of fracture of the ulnar styloid. Approximately fifty per cent. of the ulnar fractures occur at the base of the styloid. Lateral displacement of the ulnar styloid also occurs when the radius is impacted. The lateral displacement of the ulnar fragment occurs much more frequently than medial displacements and in most cases is a true shift rather than angulation. It is believed that the fracture of the smaller bone is produced by a sudden pull of the intra-articular fibrocartilage and the ulnar collateral ligament. Direct trauma is negligible in producing the ulnarfracture. The evidence for these factors is succinctly stated in a well illustrated article.—*I. William Nachlas, M.D., Baltimore, Md.*

SO-CALLED FIBROSARCOMA OF BONE. Bone Involvement by Sarcoma of the Neighboring Soft Parts. Charles F. Geschickter. *Arch. Surg.*, XXIV, 231, Feb. 1932.

Analysis is made of those sarcomata which originate in the neighboring soft parts and invade the bone by direct extension. In general, these are fibrosarcomata arising from the investing portion of the periosteum, or from a similar connective tissue or fascia investing muscles, vessels, or nerve trunks. In a review of 1700 neoplasms involving bone, there were fifty cases of this type, —thirty-one were of the fibrospindle-cell series, fourteen of the neurogenic type, one was a rhabdomyosarcoma, three angiomata and one liposarcoma. The diagnosis from the clinical history and the roentgenologic and microscopic appearances is discussed. From a study of all these cases the author draws the following conclusions as to the best method of treatment in the various types:

(1) In the fibrospindle-cell series, where the cells are of the spindle type, local removal is justifiable; but if recurrence occurs, amputation should be resorted to. In the oat-cell type, primary amputation when possible is advocated.

(2) In the neurogenic sarcoma group, primary amputation is the treatment of choice.

(3) In angiomata of bone, local excision is warranted, preferably reenforced by irradiation.

(4) For lipomata local operation is indicated; and in rhabdomyoma, amputation.—
I. William Nachlas, M.D., Baltimore, Md.

DIE VERSCHIEDENEN SAKRALISATIONSFORMEN DES 5. LENDENWIRBELS IN IHREN BEZIEHUNGEN ZU KREUZSCHMERZEN. (The Various Forms of Sacralization of the Fifth Lumbar Vertebra in Their Relation to Low Back Pain.) H. Meyer-Borstel. *Beitr. z. Klin. Chir.*, CLIII, 12, 1931.

The author has made an analysis of 1200 roentgenographs of the fifth lumbar vertebra and found a sacralization in four and five-tenths per cent. He states that sacralization is not as common as it is reported by some writers and that an unusually high incidence is probably due to faulty x-ray technique.

As a result of his own observations, the writer makes the following classification:

1. The unilateral or bilateral incomplete sacralization. The transverse process is abnormally enlarged downward but not in contact with the sacrum.
2. The bilateral bony sacralization. Both transverse processes are in bony union with the sacrum.
3. Sacralization with bilateral nearthrosis with the sacrum.
4. Sacralization with bony union on one side and a nearthrosis on the other.
5. Unilateral bony union with the sacrum.
6. Unilateral nearthrosis.

In Group 1 (2 cases), Group 2 (11 cases), and Group 4 no symptoms of low back pain were present, and the deformities of these groups have no pathological significance.

Group 3 consists of 11 cases. Clinical reports show that low back pain was present in six cases, of which five had a compensatory scoliosis. The other five cases had no such symptoms.

In Group 5, two of the seven cases suffered from low back pain, and three had a mild scoliosis.

Group 6 consists of twenty-four cases, of which twenty-three complained of low back pain. In addition, scoliosis and osteo-arthritic changes were frequently present.—*R. J. Dittrich, M.D., Wichita, Kansas.*

ÜBER VERZÖGERTE FRACTURHEILUNG (Delayed Union of Fractures). L. Michaelis. *Beitr. z. Klin. Chir.*, CLIII, 153, 1931.

In a series of fifty-nine cases of fracture of the tibia, union was delayed in eleven cases. An increase in the incidence of delayed union has, in recent years, been noted by numerous observers. No satisfactory explanation can be given, either for the occurrence of delayed union, or for the increase.

In the discussion, Hufschmid stated that he obtained very good results in five cases of delayed union, by the injection of thyroxin. In one case of fourteen months' duration, this method failed.—*R. J. Dittrich, M.D., Wichita, Kansas.*

A CASE OF GENERALIZED FIBROCYSTIC DISEASE OF THE BONES. E. W. C. Bradfield. *British J. Surg.*, XIX, 192, Oct. 1931.

The patient was first seen in Madras in 1913 at the age of six with cysts in both humeri, the shaft of the right femur, the left femur, and the left tibia. At this time a facture through a cyst in the femur healed without incident. In 1920 enlargement of both humeri and both lower extremities was noted. In 1921 a piece of ox rib was grafted into the cystic humerus, but the graft quickly absorbed and produced but little formation of new bone.

In 1929 the patient, now a grown man, was again seen. Comparative roentgenograms are shown. The bones are now harder and less tender but the process as seen by roentgenograms has shown little change. No etiological factor has ever been found. No operation has been done on the parathyroids.

Microscopically, the tissue showed marked transformation of bone into fibrous tissue and cartilage. There were no gross cysts, suggesting that this case is not one of parathyroid overactivity.

HYPERPARATHYROIDISM: GENERALIZED OSTEITIS FIBROSA (WITH OBSERVATIONS UPON THE BONES, THE PARATHYROID TUMOURS, AND NORMAL PARATHYROID GLANDS BY H. M. TURNBULL). Donald Hunter. *British J. Surg.*, XIX, 203, Oct. 1931.

A brief review of the research on the parathyroid hormone and its effect on calcium and phosphorus excretion is given. Generalized osteitis fibrosa as described by von Recklinghausen shows extensive pathological resorption of all the bones, with multiple foci of osteitis fibrosa with or without benign giant-celled tumors and cysts. Patients suffering from this malady show the same excessive excretion of calcium and phosphorus shown by patients treated with parathormone. This led to a search for tumors of the parathyroid as an etiological factor. Many such tumors have been found.

The author gives in detail the methods of studying the calcium metabolism, the diet used, and the laboratory studies used in the suspected case. He then reports four cases in great detail and in three he noted the effect of removal of parathyroid tumors,—definite regression. The operative technique is described. Osteomalacia and focal osteitis fibrosa are reviewed and the essential differences from generalized osteitis fibrosa are mentioned.

REGENERATION OF THE INTERNAL SEMILUNAR CARTILAGE AFTER OPERATION. A. Gibson. *British J. Surg.*, XIX, 302, Oct. 1931.

The author quotes a case in which a second operation on an internal semilunar cartilage, after removal two months previously, revealed complete regeneration of the cartilage. Two dogs were then subjected to complete removal of the cartilage. At autopsy on one of them it was found that the cartilage had been replaced. Microscopic examination showed dense fibrous tissue, but with no cartilage cells.

EXPOSURE OF THE KNEE JOINT. H. B. Devine. *British J. Surg.*, XIX, 306, Oct. 1931.

A new transverse incision is described.

1. A curved incision, the middle of which is about half an inch below the lower margin of the patella, is made. The skin flap is dissected up.

2. With a butcher's saw, a cut is made through the quadriceps tendon one-half inch above the patella's upper margin, sloping backward, dividing the patella and coming up posteriorly through the patellar ligament half an inch below the patella.

3. The knee is now bent, the patellar fragments separate, and the operator divides the lateral expansions until proper exposure is obtained.

4. After the operative work has been completed in the knee joint, the wound is closed with the leg in extension. The patellar fragments are fixed by catgut suture of the divided quadriceps and patellar tendons. The synovial membrane and the quadriceps expansion are sutured separated.

The advantages are claimed to lie in better exposure with resulting decrease in operative trauma.

SPONDYLOLISTHESIS. Norman Capener. *British J. Surg.*, XIX, 374, Jan. 1932.

This paper is based on a study of thirty-four cases, fifty-three per cent. in males. The most unusual type of spondylolisthesis is that in which the fifth lumbar vertebra slips forward upon the sacrum and carries the rest of the spine with it. The one most frequently seen consists of the separation of the fifth lumbar vertebra into two portions by a solution of bony continuity in the laminae posterior to the transverse processes, in such a way that the part bearing the spinous process and inferior articular surfaces moves backwards while the rest of the vertebra slips forward upon the sacrum.

The place of trauma in producing the subluxation and the influence of other factors besides lordosis are discussed. The author believes that the sacrum acts as a wedge, the apex of which is driven upwards and causes a diastasis of the last lumbar vertebra, and that the posterior portions of the lumbar vertebrae take a more active part in the production of spondylolisthesis than is usually recognized.

Early treatment consists of the usual treatment of a postural backache. Operation should be reserved for patients who do not respond to this treatment. Bone grafts may help some patients, but the ideal fixation by a bone graft—fixation of the body of the fifth lumbar to the sacrum—is technically impossible.

THE PATHOLOGY AND TREATMENT OF TUBERCULOSIS OF THE KNEE-JOINT. G. R. Girdlestone. *British J. Surg.*, XIX, 488, Jan. 1932.

Tuberculosis of the knee joint is always secondary to tuberculosis in some other part of the body.

Stereoscopic examination distinguishes three groups: (1) the extra-articular type, arising outside the joint, (2) focal-articular with bone foci communicating with the joint and (3) non-focal with no foci seen by roentgenogram. Treatment of each type is discussed. Great emphasis is laid on the usual general treatment of tuberculosis, this to be kept up even after operative treatment.

The aim of local treatment is the restoration of full movement; and, failing that, bony ankylosis. Operative fusion is discussed, its rationale, its indications, its technical points, its contraindications and its failures. On the whole it is highly successful; but it should be avoided in those too young, too old, too ill, or obstinately septic.

A tuberculous sinus is a dangerous complication because its pyogenic infection is a disaster difficult to avoid. Amputation is done as a life-saving measure only when there is a contra-indication to or a complication from other operative treatment. Arthroplasty has no place in the treatment of tuberculosis.

Some Common Complaints Amenable to Spinal Treatment. Thomas Marlin. *British Med. J.*, II, 746, Oct. 24, 1931.

Marlin touches upon a subject which deserves more thorough investigation. He states that spinal manipulation will cure or relieve a wide variety of conditions. He is frank in admitting that he has no knowledge of how this improvement is brought about, though he speculates on certain possible mechanisms. He then cites a great number of cases suffering from a variety of conditions which he has improved by spinal manipulation,—lumbar pain, stiff back, pain associated with menopause, menstrual disturbances, constipation, loss of appetite, herpes zoster, and asthma. While some of the conditions obviously might be benefited by forced movements of the spine, it is hard to believe that such conditions as asthma can be even remotely influenced by spinal manipulation.—*R. I. Harris, M.B., Toronto, Canada.*

Acute Osteomyelitis. *British Med. J.*, II, 896, Nov. 14, 1931.

This is the report of a discussion on osteomyelitis before the Section on Surgery of the Royal Society of Medicine. The subject was opened by Gwynne Williams and an extensive discussion on treatment followed. Opinions were about equally divided in favor of:—Starr's method of draining the metaphysis by drill or triphine hole; the old gutter operation, and Orr's method of vaselin pack. No agreement seemed to be reached.—*R. I. Harris, M.B., Toronto, Canada.*

Recognition and Treatment of Birth Injuries in the Newly Born. G. B. Fleming. *British Med. J.*, II, 481, Sept. 12, 1931.

This is an important paper upon a subject which all too frequently is the basis of later orthopaedic deformities. Its importance is due to the fact that it is based on actual figures,—350 cases of birth injury among 8,000 births during a period of three and one-half years. All the recognized forms of birth injury occurred. The treatment is discussed.—*R. I. Harris, M.B., Toronto, Canada.*

Bone Graft and Fusion Operations for the Spine. S. A. S. Malkin. *British Med. J.*, I, 5, Jan. 2, 1932.

This article is the description of a new technique for spinal bone graft. The spinous processes and laminae are denuded of soft tissues on both sides and a suitably curved graft, cut from the tibia, is fitted on either side of the spines. The advantages claimed are greater adaptability to deformity and greater strength of fusion.—*R. I. Harris, M.B., Toronto, Canada.*

The Transplantation of Bone. W. E. Gallie. *British Med. J.*, II, 840, Nov. 7, 1931.

This paper, read at the opening of a discussion at the Section of Orthopaedic Surgery of the British Medical Association Meeting at Eastbourne in 1931, is deserving of the most careful perusal. Within its limits it condenses the wisdom born of long experience. Every dictum is based on abundant and careful observations and is sound. By approaching his subject from the point of view of difficulties and failures of treatment, Dr. Gallie is enabled to discuss all the important steps in bone-graft technique, and the principles which underlie the attainment of success.—*R. I. Harris, M.B., Toronto, Canada.*

Lengthening of the Lower Extremities. LeRoy C. Abbott. *California and Western Med.*, XXXVI, 6, Jan. 1932.

During the past six years there have been forty-eight cases of tibial lengthening and twenty-five femoral lengthenings done in the Shriners' Hospital for Crippled Children,

in St. Louis after the manner described by the author. Three fundamentals of technique were followed: first, traction and countertraction must be made upon the bone directly; second, the traction must be slow and continuous; and, third, accurate alignment of the fragments must be maintained.

For lengthening the tibia and fibula, two stainless steel drill pins are passed through both the upper and lower ends of the tibia with the skin pulled toward the center of the leg. Uniform directions are maintained by means of a pin guide which is held firmly to the leg while the pins are being drilled through. To the two proximal pins are attached two plates, made stationary to the traction and supporting splint; and to the two distal ones are attached two movable plates. These paired plates are moved apart, gradually separating the bone fragments, by means of thumb screws and coil springs. The tibial osteotomy is performed through a five-inch curved incision, which goes through to the bone, so as not to disturb the blood supply to the periosteum. The tibia is split longitudinally with the motor saw and the anterior one-half is cut transversely at its distal extremity, while the posterior one-half is cut transversely at its proximal end. The fascia covering the peroneals and their mesial fascia bands are severed transversely at the time of the osteotomy of the fibula.

In lengthening the femur several methods were used, but the author believes the preferable one is to insert the two lower pins horizontally, as in the tibia, while the upper fragment is held by a single vertical pin inserted in the sagittal plane. Scrupulous care must be observed to prevent infection, especially from the gluteal region. The author believes that piano-wire pins would be preferable in the upper thigh because of this danger.—*Charles Lyle Hawk, M.D., Los Angeles, California.*

La Tubercolosi Primitiva della Rotula (Studio Clinico e Anatomo-chirurgico). Ricostituzione Rotulea con Autotrapianto Osseo (Metodo Leotta). [Primary Tuberculosis of the Patella: Reconstruction by Bone Autotransplant.] A. Pirrone. *Chir. d. Org. di Movimento*, XVI, Fasc. 4, 324, Sept. 1931.

The primary tuberculosis of the patella is rare and is given very little attention in the textbooks on surgery. More recently Crainz and Patel have reported and studied the condition.

The author reports one case in which tuberculosis of the patella was the only tuberculous process which could be established. The condition remained unobserved for a considerable length of time and it was difficult to differentiate from tuberculosis of the knee. The lesion presents itself in several forms,—in the fungus form, in the caseous form, or in the dry atrophic form. Only exceptionally diffused lesions are found; as a rule lesions are circumscribed. As far as the course is concerned, according to Patel and Marion, three phases of the tuberculosis of the patella may be distinguished,—the period of pain, that of abscesses, and that of arthritis of the knee.

So far as the treatment is concerned, all authors are agreed that operative interference is necessary in tuberculosis of the patella. After removal of the patella, regeneration occurs only in children in whom the patella is largely cartilaginous. Because of the great functional disturbances which follow the entire removal of the patella the author recommends that after removal of the bone, an autoplastic bone transplant be made, and he has carried out this method in his own case which he describes minutely.—*A. Steindler, M.D., Iowa City, Iowa.*

Trazione col Filo. (Wire Traction). V. Putti. *Chir. d. Org. di Movimento*, XVI, Fasc. 4, 395, Sept. 1931.

Presentation of the technique of the author's modification, and of the development of the method of wire traction, inaugurated by Klapp and Kirschner. The author used, in later cases, the perforator of Johansson which seems to be simpler and more rational than the so called "accordion" perforator of Kirschner. He describes the technique of the insertion of the wire, the fastening and stretching, etc. Commencing with a smaller force, the amount of traction is gradually increased and the traction is applied

by means of a pulley system over an inclined splint attached to a gas-pipe frame. When satisfactory reduction has been obtained, immobilization is established by means of a plaster cast.—*A. Steindler, M.D., Iowa City, Iowa.*

DIE OSTITIS FIBROSA RECKLINGHAUSEN, IHRE ABTRENNUNG VON ANDEREN KNOCHENERKRANKUNGEN. [Osteitis Fibrosa (Recklinghausen), Its Differentiation from Other Bone Diseases.] Heinrich Schupp, *Deutsche Ztschr. f. Chir.*, CCXXXIII, 195, 1931.

Following an extensive discussion of the various theories used to explain this group of bone diseases, the author describes two cases in detail. The first was a somewhat unusual case of osteitis fibrosa (Recklinghausen), in which the epithelial body tumor was situated within the thyroid gland. The brown tumors and cysts, usually conspicuous in the bones, were absent. Only the careful study of the clinical and x-ray findings revealed the probability that a cyst had been present, which was no longer recognized, owing to a spontaneous fracture. Small brown tumors were detected in a careful examination of the skeleton. The second case was one of high-grade senile osteoporosis in which the clinical and anatomical findings led to interesting possibilities of diagnosis (characteristic marrow cysts with giant cells, so called lipoblasts).

The one-sided doctrine, based on histopathological studies of various bone diseases,—osteomalacia, rickets, osteitis fibrosa Recklinghausen, localized osteitis fibrosa, and osteitis deformans Paget—grouped diseases which in their nature, origin, clinical aspects, and prognosis were very different. Along with the progress made by research, there arose urgent reasons for separating these diseases. For a long time this doctrine has been considered inadequate for a proper understanding of the conditions, especially since the relationship between epithelial bodies and bone diseases has been recognized. The discovery of the etiological significance of epithelial body tumors associated with osteitis fibrosa Recklinghausen was of great importance. Today all these bone diseases are considered to be essentially different from each other. Although the etiology for all bone diseases is not known, it has been established that it is not the same in all conditions. It must be considered certain that osteitis fibrosa Recklinghausen is an endocrine disturbance, brought about by the development of benign epithelial body tumors. It is therefore approachable by means of surgical measures.

An important feature in the microscopic diagnosis of osteitis deformans Paget is the "mosaic structure" of the reformed bone. For this disease it is conceivable that it may be transformed into a generalized condition, provided a common cause can be found. It is ordinarily classified as a localized affection.

For the anatomical diagnosis, it is necessary to make extensive macroscopic and microscopic examinations.—*R. J. Dittrich, M.D., Wichita, Kansas.*

DIE LUXATIO CLAVICULAE ACROMIALIS UND IHRE BEHANDLUNG. (Acromioclavicular Dislocation and its Treatment.) Hans Mannheim. *Deutsche Ztschr. f. Chir.*, CCXXXIV, 573, 1931.

The mechanism of production of this injury is one in which a blow or fall on the shoulder is combined with a relaxation of certain muscles. Depending on the extent of the force, the luxation may be incomplete, in which only the acromioclavicular ligaments are torn; or complete, in which the powerful coracoclavicular ligaments are also ruptured. A separation of the joint surfaces of less than one and a half centimeters indicates an incomplete dislocation, whereas a greater separation must be taken as evidence of tearing of the coracoclavicular ligaments. The extent of the separation can be easily determined with a tape-measure, but roentgenographically it may be overlooked, due to faulty projection of the rays.

With regard to treatment it is immaterial whether the dislocation is complete or incomplete; a distinction is necessary, however, as an indication in deciding on either conservative or operative treatment. The numerous methods of bandaging which have

been described are efficacious only as long as the bandages are left in place. For conservative treatment all patients are excluded who are incapacitated for labor, or otherwise present *serious symptoms*. In the reexamination of patients it was noted that it was impossible to lift even light weights.

The operation for this injury is performed under local anaesthesia. A curved incision, convex posteriorly, is made over the joint. The joint surfaces are exposed and approximated manually. A wire drill is inserted through the acromium and extended about three or four centimeters into the clavicle. This drill is left in place for four weeks. After removal the after-treatment, consisting of application of heat, massage, and exercises, is instituted. In the experience of the author, the dislocation is permanently cured following this procedure.

Of thirty-two patients seen since 1908, twenty-three were *treated conservatively* and nine were subjected to various operations. Three were treated with the method here described. *R. J. Dittrich, M.D., Wichita, Kansas.*

Die Trophische Extremitätenstörung durch Periphere (Infectiöse und traumatische) Reize. [Trophic Disturbances of the Extremities Caused by Peripheral (Infectious and Traumatic) Stimuli.] P. Sudeck. *Deutsche Ztschr. f. Chir.*, CCXXXIV, 596, 1931.

A powerful inflammatory stimulus normally alters the trophic function of all portions of the extremity, not only locally, but also collaterally, through the medium of the inflammatory hyperaemia. Overstimulation by serious and prolonged disease conditions may lead to a fatigue of the reaction and an atonic hyperaemia, and thus to a condition which is designated as a dystrophy. Dystrophies of the extremities may also appear with apparently mild stimuli, especially joint injuries, as an expression of constitutional dysfunction of the vegetative nervous system.—*R. J. Dittrich, M.D., Wichita, Kansas.*

Die Subcutane Spätruptur der Sehne des Extensor Pollicis Longus nach Radiusfractur und Anderen Knochenveränderungen in der Nähe der Rissstelle. (Late Subcutaneous Rupture of the Tendon of the Extensor Pollicis Longus Following Fracture of the Radius and Other Bone Changes Near the Site of Rupture.) Alfred Horwitz. *Deutsche Ztschr. f. Chir.*, CCXXXIV, 710, 1931.

The author states that he has been able to find reports of only twenty-four cases in the literature. During the last three years he has observed four cases. Of these, two followed fracture of the radius, one followed fracture of the first metacarpal, and one followed a cystic condition of the styloid process of the radius. Repair of the tendons by uniting the ends with silk sutures has yielded very good functional results.

The mode of origin and the nature of this injury are not fully understood. The rupture is neither purely traumatic nor purely pathological. The primary cause of the condition is probably a nutritive disturbance of the tendon, produced as a result of the trauma. Following this disturbance, the tendon tissue undergoes regressive changes and loses its tensile strength. Depending on the extent of the tendon injury, it takes weeks or months until the tendon is completely torn, without any external influence, or any particular functional demands.—*R. J. Dittrich, M.D., Wichita, Kansas.*

Zur Frage der Endresultate der Unblutigen Behandlung der Angeborenen Hüftgelenksverrenkung. (End Results of Bloodless Treatment of Congenital Dislocation of the Hip.) Heinz Beck. *Deutsche Ztschr. f. Chir.*, CCXXXIV, 723 1931.

The author has made an analysis of end results in patients whose immediate results were functionally and anatomically correct. This study revealed a high percentage of poor results occurring during adolescence. Only one-third of the cases reexamined could be designated as being permanently cured, clinically and roentgenographically.

In a small portion without clinical symptoms, the x-ray examination showed beginning unfavorable conditions. The majority of the cases showed functionally and roentgenographically a regression, caused mainly by a defective development of the acetabulum, especially in its upper portion, and disturbances of growth in the roof of the acetabulum.

Any further improvement in our technique of reduction may well improve our immediate results, but will not prevent the late changes.

The fate of the patient cannot be decided before adolescence. With the appearance of symptoms it is possible by relief from weight-bearing, or by a plastic operation on the roof of the acetabulum, to prevent an aggravation of symptoms, provided the head is still in the socket. If the head has proceeded upward, however, then only an osteotomy can produce a functional improvement.

The analysis is based on examination of 162 dislocations in 115 patients. The principal causes of disability were coxa vara, coxa valga, defective development of the acetabulum, and disturbances of growth in the roof of the acetabulum.—*R. J. Dittrich, M.D., Wichita, Kansas.*

Slipping of the Upper Femoral Epiphysis. A Study of Seventy Cases. Albert B. Ferguson and M. Beckett Howorth. *J. Am. Med. Assn.*, XCVII, 1867, Dec. 19, 1931.

In reviewing seventy cases of slipped upper femoral epiphysis the authors found that overweight children were more susceptible to the condition due to greater stress on the hip, that trauma played an important part by merely adding insult to a hip already injured by infection, and that the condition occurs during the rapid growth period of adolescence. The pathological picture is that of sclerosis about the neck, followed by vascular disturbances. This results in weakening at the epiphyseal disc, predisposing to slipping.

Preslipping, slipping, quiescent, and residual stages are described. For best results from treatment early diagnosis is necessary. Rest is the most important factor in preslipped hips and in hips that have slipped less than three-eights of an inch. More than three-eights of an inch slipping early in the disease and recently should indicate closed reduction. In old cases with that much slipping, open reduction or subtrochanteric osteotomy is advised. There is no relation between deformity and function.—*Ruth Jackson, M.D., Dallas, Texas.*

Scoliosis. Etiology, Pathogenesis, and Prevention of Experimental Rotary Lateral Curvature of the Spine. Eben J. Carey. *J. Am. Med. Assn.*, XCVIII, 104, Jan. 9, 1932.

The author gives an interesting discussion of the etiology, pathogenesis, and prevention of experimental rotary lateral curvature of the spine. Scoliosis is a special sign of the imbalance of muscle and bone growth of the motor system of the back. The most frequent insidious cause of idiopathic structural scoliosis is chronic inanition and malnutrition.

The types of scoliosis were studied by the use of a dynamic muscle-bone balance model of the spine. It is almost impossible to conceive the number of possible combinations of muscular imbalance, and it is almost impossible to assign to any single muscle group or combination of muscle groups the cause of a specific curvature of the spine. The convexity of the laterally deviated spine may be toward either the stronger or weaker muscle side, depending upon the group of muscles involved. The degree of rotation also depends upon the group of muscles involved.

The problem of scoliosis, it is concluded, is fundamentally one of prevention of all conditions which upset the normal dynamic balance of muscle and bone during the growth period, which leads to undernourishment of the child.—*Ruth Jackson, M.D., Dallas, Texas.*

Surgery of Suppuration in the Fascial Spaces of the Thigh. J. E. Milgram. *J. Am. Med. Assn.*, XCVIII, 117, Jan. 9, 1932.

Dr. Milgram gives an interesting presentation of the fascial spaces of the thigh as described by Dr. Henry J. Prentiss, late professor of Anatomy at the University of Iowa. The anterior and posterior compartments communicate over the greater trochanter under the "vaginal" fascia, and the popliteal space belongs in a special sense to the leg and not to the thigh. *Once in these spaces or compartments, pus may travel a very long way into communicating spaces.* Compartment infections may be initiated by infected hematomata of a compartment, diabetic "cellulitis", embolization after operative procedures, direct introduction, and extension of nearby purulent foci.

Treatment requires *accurate* preoperative localization of the primary focus, efficient *drainage of same and of involved compartments.—Ruth Jackson, M.D., Dallas, Texas.*

Absence of the Cervical Spine. Klippel-Feil Syndrome. George I. Bauman. *J. Am. Med. Assn.*, XCVIII, 129, Jan. 9, 1932.

Six cases showing *Klippel-Feil syndrome*, or numerical variation of the cervical vertebrae, with more or less complete fusion into one mass accompanied by other anomalies, are presented.

The classic symptoms are absence or shortening of the neck, lowering of the hair line on the back of the neck, and limitation of motion. Other symptoms may be present, such as torticollis, mirror movement, facial asymmetry, dorsal scoliosis, difficulty in breathing and swallowing.

Treatment is of no avail. Prognosis as to life is good.—*Ruth Jackson, M.D., Dallas, Texas.*

Fractures of the Upper End of the Humerus. Sumner M. Roberts. *J. Am. Med. Assn.*, XCVIII, 367, Jan. 30, 1932.

Twenty-six cases of injuries to the upper end of the humerus above the level of the surgical neck are discussed. Fracture of the greater tuberosity, usually associated with other fracture or dislocation, is best treated by fixation in abduction. If dislocation is present, the fractured fragment usually returns to position, when the dislocation is reduced. Open operation is usually indicated in epiphyseal separations for exact reposition. *Transverse fractures of the surgical neck occur in young people*, are prone to displacement, and frequently require open operation. Comminuted fractures occur in elderly people and since displacement is not a feature, simple fixation suffices and early motion is desirable. There is a marked tendency to dispense with prolonged fixation and the position of abduction, and use simpler fixation and early active motion. The results are satisfactory.—*Ruth Jackson, M.D., Dallas, Texas.*

Pulmonary Infarction and Pulmonary Embolism in Orthopedic Surgery. Carl E. Badgley and F. Janney Smith. *J. Am. Med. Assn.*, XCVIII, 467, Feb. 6, 1932.

Very little has been written concerning pulmonary complications in orthopaedic cases. In one year eight cases of infarction and one of embolism occurred in the Orthopaedic Service of the Henry Ford Hospital.

Pulmonary infarction and embolism are not uncommon complications after fracture of the lower extremities or operation on them. The appearance of clinically recognizable femoral thrombophlebitis renders the probability of subsequent fatal pulmonary embolism unlikely. The interval between fracture and infarction is longer than between operation and infarction.

Local treatment should be withheld in any fracture case presenting pleural pain, unexplained temperature, or bright blood in the sputum.

The oxygen tent is of value in allaying respiratory distress in moderate-sized pulmonary infarctions.—*Ruth Jackson, M.D., Dallas, Texas.*

A NEW OPERATION FOR RECURRENT DISLOCATION OF THE SHOULDER. Edson B. Fowler. *J. Am. Med. Assn.*, XCVIII, 476, Feb. 6, 1932.

An operation for recurrent dislocation of the shoulder, which is easy to perform, does not violate the mechanical or physiological laws, gives a permanent cure with a perfect function in practically all cases, and requires a short period of disability, is here described.

A fascial strip is passed through a drill hole in the coracoid process, through an opening in the mid-anteromesial portion of the capsule under the neck of the humerus, and through the capsule mid-posteriorly between the teres minor and infraspinatus, and then through a drill hole in the acromion. The arm is abducted to ninety degrees and the fascial strips drawn taut under the neck of the humerus, and the fascial ends sutured back on themselves.

Arm is carried in a sling for ten to fourteen days; at the end of six to eight weeks there is normal function.—*Ruth Jackson, M.D., Dallas, Texas.*

HYPOCALCEMIA FOLLOWING EXPERIMENTAL HYPERPARATHYROIDISM AND ITS POSSIBLE SIGNIFICANCE. A. Bodansky and H. L. Jaffe. *J. Biol. Chem.*, XCIII, 543, Oct. 1931.

Parathormone injection into a series of guinea pigs produced the experimental hyperparathyroidism with hypercalcaemia. Hypocalcaemia observed several days after discontinuance of parathormone administration was considered as due to a rapid redeposition of calcium in the previously depleted bones; phosphorus retention was associated with this hypocalcaemia. It is also suggested that a temporary dysfunction of the parathyroid glands may have been caused by the prolonged parathormone administration. This, the authors believe, may explain analagous developments following removal of parathyroid adenomata in osteitis fibrosa cystica.—*W. Hamsa, M.D., Iowa City, Iowa.*

INDICATIONS AND TECHNIQUE OF ARTHRODESIS FOR TUBERCULOSIS OF THE HIP. A. Richard and A. Elbim. *J. de Chir.*, XXXIX, 1, Feb. 1932.

The authors discuss the evolution of the bone graft in arthrodesis of the hip and insist upon prolonged immobilization, because up to a certain point the graft undergoes absorption. They believe that the arthrodesis is contra-indicated in cases with renal tuberculosis or where there are other severe visceral lesions. Likewise, it is contra-indicated when there is ankylosis of the opposite hip and when there is an abscess in the region of the operative incision. It is also dangerous to operate upon a very acute tuberculous hip with marked adenopathy and infiltration of the periarticular tissues.

In children the authors believe that tuberculosis of the hip often heals under orthopaedic treatment either by immobilization in plaster or continuous traction and, depending upon the severity of the disease, the results may be absolute ankylosis or a useful range of movement may be obtained. However, there are certain cases which do not heal without operative intervention. One type is that in which, after three or four years of conservative treatment, the disease is still active. Another type is that in which there is a relapse after an apparent cure. A third type is that in which the disease is apparently rapidly progressive and very severe with marked destruction of the acetabulum.

In other words, the authors believe that in adults all cases should be arthrodesed, but that the operation should be done at an opportune time; while in children severe cases should be arthrodesed, and mild cases should be treated conservatively and then operated upon if conservative treatment does not effect a permanent cure within three or four years.

They discuss the technique and describe two procedures for extra-articular arthrodesis. One is through a Z-shaped incision. The anterior portion of the wing of the ilium and the great trochanter are exposed, and a large thin pedicle graft is turned downward from the ilium and inserted into a graft in the trochanter. In the other the trochanter and ilium are exposed through a straight lateral incision and a wide thin osteoperiosteal graft from the tibia is placed across the space between the trochanter and the ilium, [illegible]

end being inserted under a bone flap in the ilium and the other into the split trochante The authors favor the flexible graft from the side of the ilium and report fifty-three case seven of which were in adults.—*J. Albert Key, M.D., St. Louis, Missouri.*

SURVEY OF ANTERIOR POLIOMYELITIS AT GRASSLANDS HOSPITALS. Bernard Charl Hecht. *Med. J. and Record*, CXXXIV, 19, Jan. 6, 1932.

A review of the cases of anterior poliomyelitis treated in the Grasslands Hospita over a seven-year period, starting in 1925 with three cases and ending with ninety-si cases in 1931, is given. The age incidence was greatest up to five years. Gastro intestinal upsets were prominent in the prodromal symptoms. The author advocate spinal taps in suspected cases. The usual spinal fluid cell count was below 200 cell per centimeter, but cell counts over 1000 were observed. As a rule, the high cell count indicated a poorer prognosis The cell count had a tendency to drop rapidly and by th fourth week was practically normal.

Seventy-five to one hundred cubic centimeters of convalescent human serum wa given by all routes. He gained the clinical impression that the serum was of some value however, certain cases went on to paralysis despite serum therapy while some had weakness of muscle groups which cleared up within three weeks. The mortality rate of cases of true bulbar paralysis remained about the same in spite of the use of the Drinker apparatus.

The author believes that the large number of cases which have recovered without paralysis may be due to the fact that the abortive type is more often recognized. The follow-up care of supposed abortive cases he considers just as important as the treatment of paralyzed cases, since some later exhibit imbalance of intrinsic muscle groups which lead to deformities.—*Robert Zollinger, M.D., Cleveland, Ohio.*

TUBERCULOSIS OF THE DIAPHYSIS OF THE FEMUR. William L. Corcoran. *Med. J. and Record*, CXXXIV, 109, Feb. 3, 1932.

The author reports a case which clinically was tuberculosis about the knee joint. However, roentgenograms suggested that there was periosteitis in the lower third of the femur with a synovial effusion. The patient was a white girl, ten years old, with a strong family history of tuberculosis. She had complained of pain, tenderness, and disability of the left knee for one month. The patient responded to treatment for tuberculosis and in two and one-half years she was attending school. There was no shortening of the left leg. Roentgenograms showed a residual osteomyelitic involvement with osteoporosis in the area of the knee. The author points out that a joint may be involved by extension from the periosteum of the shaft and *vice versa* if the capsule extends beyond the epiphyseal plate.—*Robert Zollinger, M.D., Cleveland, Ohio.*

ABORTIVE POLIOMYELITIS: REPORT OF TWO CASES. J. H. Musser and L. A. Monte. *New Orleans Med. and Surg. J.*, LXXXIV, 475, Dec. 1931.

Two cases of this disease are reported as follows: Colored girl, aged nineteen years, was admitted to the New Orleans Charity Hospital on September 25, because of headache and stiffness of the neck. Physical examination showed nothing further than rigidity of her neck muscles and temperature on admission 102. Lumbar puncture showed a cell count of 750 with seventy per cent. polymorphonuclears and thirty per cent. lymphocytes. Globulin was one plus; Wassermann, negative; no organisms were observed in the culture or smear. Second day, temperature normal and remained so. Lumbar puncture few days later showed clear fluid not under pressure; cell count had fallen to 180. Patient discharged six days after admission without any evidence of involvement of the central nervous system.

Second similar case is reported; the authors say that they are unaware of any morbid conditions except poliomyelitis which would cause an increase in the spinal cell count comparable to these reported, and which had been followed by such a prompt drop.

It is the mild cases which presumably are responsible for the spread of poliomyelitis.—*Edward S. Hatch, M.D., New Orleans, Louisiana.*

Postoperative Use of Therapeutic Pools. C. L. Lowman. *Northwest Med.*, XXX, 538, Dec. 1931.

The hydrogymnasium was established in the Orthopaedic Hospital-School in Los Angeles in 1924. The patients are lifted into and out of the water on an electrically operated table, and acute, chronic, and postoperative cases of poliomyelitis are treated under water; also spinal fusion cases of Pott's disease, scoliosis, and fractures are exercised while in waterproof splints, muscle exercise and stimulated metabolism being obtained without spinal movement. A much wider range of movement can be obtained without muscle spasm. In the spinal fusion cases the treatment may begin by the eighth or ninth week. Reduced congenital hips can obtain knee and ankle bending with active abduction and extension, followed by "straddle walking" with the greatest ease in the buoyant water without danger of slipping and falling. This shortens the period of inactivity and circulatory stasis, and the expense of hospitalization is diminished from fifteen to twenty-five per cent. The rule is to use only active motion of the affected joints within a painless arc. Inhibitory spasm does not occur, because the patient's attention is directed toward distal normal parts and away from the operated area. Tendon transplants are activated earlier and with greater safety through gravity elimination in water. With the water up to the axillae the patient's weight is reduced to from one-sixth to one-eighth normal. Gradually the patient exercises in shallower water, thus increasing function and weight-bearing. Compressed-air, underwater massage helps greatly in relieving muscle spasm in early follow-up treatment of fractures.

The patients with draining sinuses or infected wounds are placed in a hypertonic salt pool composed of 500 pounds sea salt and 200 pounds magnesium sulphate in 2100 gallons of water. Cases of osteomyelitis may become surgically clean in this solution. The author recites a case of open knee-joint infection which improved greatly while being exercised in this pool.

The author's conclusions are: First, underwater exercise promotes earlier return of function in operative bone and joint work than can be obtained by almost any other method. Second, the physiological use of parts affected and the rest of the body improves metabolism and hastens the healing process. Third, movement without spasm and joint friction is possible through a large arc. Fourth, motion and weight-bearing can both be accurately scaled to dosage, either separately or together. Fifth, the morale of long-drawn-out chronic cases is greatly heightened. Sixth, hospitalization time is greatly shortened, and economy results.—*Charles Lyle Hawk, M.D., Los Angeles, California.*

Syndactylizing the Fingers Preliminary to Skin Grafting. Adalbert G. Bettman. *Northwest Med.*, XXXI, 70, Feb. 1932.

The author presents a system of repair of scar-contracted fingers in which he first removes the scar tissue from the flexor surfaces and then undermines the edges of the normal skin, forming longitudinal flaps, which are turned outward and sewed edge to edge, making an unbroken wound on the volar surface of the involved fingers. This is covered by a pedicle graft from the abdomen. After ten days the fingers are separated and the raw edges sutured.

This method provides ample graft material for the denuded surfaces and, rendering the area an unbroken grafting surface, reduces infection to a minimum.—*Charles Lyle Hawk, M.D., Los Angeles, California.*

Fractures of the Leg. Improvement on the Delbet Method. John H. Besson. *Northwest Med.*, XXXI, 71, Feb. 1932.

The author discusses the merits of the Delbet splint, and emphasizes the necessity of early mobilization in ankle and lower leg fractures. He presents what he believes to be an improvement on the Delbet splint, which is made of four strips of sixteen to twenty thicknesses of crinoline basted together and impregnated with plaster cream or powder. The author uses instead ordinary plaster splints of twenty thicknesses of [illegible]

crinoline each and these are applied carefully over the bony contours of the tibial tuberosities and malleoli. Walking with or without crutches may be begun as early as ten days after the accident. *In cases of fracture in the upper portions of the tibia an unpadded case with a Böhler walking stirrup should extend to the mid-thigh.*

Internal massage, or early use of the limb, is of primary importance; if this cannot be done, then Mommsen's tapping apparatus in the heel is of benefit. The author condemns the *well-padded cast, which Calot characterizes as* "veritable *floating* trousers", and believes that they prolong *unnecessarily the disability of fracture* cases, *five to* six months for Pott's fractures and eight months for tibial and fibular fractures being entirely too long. *Charles Lyle Hawk, M.D., Los Angeles, California.*

INDICATIONS DES INTERVENTIONS SANGLANTES DANS LE MAL DE POTT DE L'ENFANT. (Indications for Surgical Intervention in Pott's *Disease of* Childhood.) André Richard et Jean Calvet. *Presse Méd.*, XXXIX, 1849, Dec. 16, 1931.

This study emanates from the Maritime Hospital at Berck-Plage and therefore merits serious consideration.

While the authors cite only eight brief case reports, these are quoted as illustrative "observations" and apparently the paper is based on a considerable number of cases of tuberculosis of the child's spine treated by open surgery.

In operations for fixation the Albee method is employed; the graft, however, is obtained *by chisel and mallet and the spinous processes are split* "by hand" without resorting to hammer pounding. It is quite evident that the authors in selected cases favor and employ this method in children over seven years old. The usual indications and contra-indications are given. The authors lay stress on continuing with the ordinary modern general antituberculous régime, such as,—heliotherapy, proper rest and food, cast and brace protection, etc., etc.

The operative cases are placed in three groups:

(*a*) Those children in which evolution of the disease is excessively prolonged.

(b) Those children who present great secondary deformities.

(*c*) *Those older children (thirteen to seventeen years) in* whose cases the vertebral lesion comports itself as in the adult.

In addition to internal bone-graft splinting, the authors occasionally resort to other surgical methods in spinal tuberculosis, *viz:*

(*a*) Resection of the spinous processes for aesthetic reasons or because of skin ulcerations over the subcutaneous bony prominences.

(*b*) Costotransversectomy (one case report). In cases of paraplegia to relieve the extradural pressure of an abscess.

(*c*) Removal of the abscess *in toto* and sequestrectomy. The authors cite two of their patients in whom this operation had been done elsewhere. As yet it has not been tried at Berck-Plage. The authors call attention to the seriousness of this surgical intervention and are not in favor of attempting the entire removal of the abscess. On the other hand they seem to be inclined to perform the latter operation (sequestrectomy) in suitable cases where the indications seem clear-cut. So far they have not done it.—*Emil S. Geist, M.D., Minneapolis, Minnesota.*

LA RÉDUCTION DES FRACTURES DE JAMBE PAR TRACTION MÉCANIQUE SOUS L' ÉCRAN RADIOLOGIQUE. (Reduction of Leg Fractures by Traction on the X-Ray Table.) Merle D'Aubigné. *Presse Méd.*, XXXIX, 1891, Dec. 23, 1931.

A worth-while report of fifty-two cases of oblique and transverse fractures of the tibial and fibular shafts. Perineal post and leg traction device are a portion of the equipment of the x-ray table. Like Böhler, the author insists on the importance of as early treatment as possible following the injury. Delay is always harmful. The author stresses: (*a*) local anaesthesia, (*b*) early reduction, (*c*) reposition by heel traction (non-skeletal) under constant x-ray control, (*d*) immobilization by plaster-of-Paris modified Delbet-Quénu cast, with little or no padding.—*Emil S. Geist, M.D., Minneapolis, Minnesota.*

L'Accélération de la Croissance des Fémurs Fracturés chez L'Enfant. (Growth Acceleration Following Fracture of the Femur in Childhood.) Pierre Marique. *Presse Méd.*, XXXIX, 1905, Dec. 26, 1931.

The author reviews the literature and adds a case of his own (a seven-year-old girl), in which the fractured femur was two centimeters longer than its fellow approximately two and one-half years after union had occurred.

The author concludes that in the femoral fractures of childhood some shortening due to malposition or overlapping can be compensated for by occasional activation of growth in length; further, that cases with good apposition and union may eventuate with too long a leg.

The author attempts to explain the process after the theories of Leriche and Policard.—*Emil S. Geist, M.D., Minneapolis, Minnesota.*

A Propos de la Verrue Plantaire. (Plantar Warts.) Marcel Joly. *Presse Méd.*, XXXIX, 1930, Dec. 30, 1931.

Since this painful and annoying condition is frequently encountered in the office of the orthopaedic surgeon, the reviewer thought it not amiss to call attention to Joly's letter. The author is electroradiologist of the *Hôpitaux de Paris.* He stresses the importance of radiations of short-wave length whether obtained from x-ray or radium sources. He calls attention to the usually brilliant, curative result of one ten-minute exposure.

(In the opinion of the reviewer, the diagnosis of this condition is often up to the orthopaedic surgeon, while the treatment had better be left to the dermatologist or radiologist.)—*Emil S. Geist, M.D., Minneapolis, Minnesota.*

Torticolis par Subluxation de l'Axis. J. Gourdon. *Presse Méd.*, XL, 92, Jan. 16, 1932.

A case report, which is well done. Indirect injury. While lifting a heavy object, the patient voluntarily turned his head suddenly and thereby forcibly produced the lesion. Reduction without anaesthesia. No postoperative dressing of any kind.—
Emil S. Geist, M.D., Minneapolis, Minnesota.

Stawy Krzyżowo-biodrowe w Świetle Najnowszych Badán. (Sacro-Iliac Articulations From Viewpoint of Recent Researches.) Z. Neyman. *Polska Przegl. Radjol.*, VI, 21, 1931.

The author tries to standardize the technique of x-ray investigation of this articulation, emphasizing particularly the taking of strictly symmetrical pictures in direct projections, showing the separation of the anterior and posterior contours of the upper and lower borders of the joint. In regard to the diagnosis of this articulation, he discusses:

1. Physiological variations,
2. Developmental anomalies,
3. Inflammatory conditions, acute or chronic,
4. Tuberculosis and syphilis,
5. Neoplasm,
6. Chronic, post-traumatic conditions with marginal sclerosis,
7. Pure trauma.

In regard to the differential diagnosis he follows and cites the statistics of Miltner and Lowendorf of our clinic.—*A. Steindler, M.D., Iowa City, Iowa.*

POURAZOWE SKOSTNIENIE PRZYKŁYKCIOWE KOLANA (t. zw. Chroba Pellegriniego if Stiedy). [Metatraumatic Paracondylomatous Ossification of Knee (Pellegrini-Stieda's Disease).] M. Ossowski. *Polski Przegl. Radjol.*, VI, 43, 1931.

After direct or indirect traumatism of the knee accompanied by very protracted complaints, the radiological examination reveals in a great number of cases the presence of a small shadow in the neighborhood of the internal condyle of the femur. From the operative findings of Pellegrini we know that these shadows are due to ossification in the connective tissue of the joint capsule in the neighborhood of the internal condyle, or to small periosteal tears about the internal condyle. Fifteen cases of this type are described by the author. He believes that the condition is due to ossification and scar tissue developed as the result of lesions of the capsule and of the capsular ligament.—*A. Steindler, M.D., Iowa City, Iowa.*

TWO CASES OF BRACHYDACTYLIA. A. E. Perley. *Radiology*, XVII, 1056, Nov. 1931.

One case was unilateral and involved the fourth metacarpal; the other was bilateral and presented shortened fifth metacarpal bones. A familial history existed in both cases.

Bilateral congenital malformations can be traced usually to heredity, while the unilateral may be explained on principles of embryonic pressure defects.—*J. Kulowski, M.D., Iowa City, Iowa.*

SOME OBSERVATIONS ON THE TREATMENT OF BONE SARCOMA. Umil G. Beck. *Radiology*, XVII, 1270, Dec. 1931.

This article recites the history of two cases of bone sarcoma under treatment and observation for a number of years.

The first, a four-year-old girl, developed a tumor of the right thigh. A tentative diagnosis of sarcoma was made and exploration, to be followed by amputation at the hip in case the diagnosis were verified, was advised. The exploration was allowed but the amputation refused. In October 1923, the exploration was made and the entire trochanter, with as much of the enlarged portion of the femur as was feasible, was removed.

Six platinum needles of radium, 12½ mg. each, unscreened and fastened to wires, were inserted into the excavation in the bone; the wound was packed with gauze and temporarily closed. The radium was removed six hours later. On October 23, 26, 29, and November 5, 37½ mg. of radium was inserted into different parts of the still open wound and left for four hours each time. X-ray treatment was given later. The wound later filled with granulations and the skin regenerated.

The patient regained her lost weight and developed into a healthy, lively child. Radiograms were made at intervals; and the last one, five years after operation, showed almost normal regeneration of the femoral neck with reenforcement of the bone lining the old cavity. The patient was reported, in November 1930, as being perfectly well.

The second case, a woman, developed a tumor of the left wrist in November 1907. She was then thirty years of age. Dr. N. Senn diagnosed it as a very malignant type of sarcoma, and advised amputation above the elbow. This was refused, but removal of two carpal bones was allowed. The tumor invading these bones proved to be osteogenetic sarcoma. The author gave after-treatment with the crude x-ray apparatus of that day, with no measurement of dosage.

There was prompt recurrence and amputation below the elbow was done on June 1, 1907. Six months later a small growth appeared in the scalp of the occiput, which was removed and proved to be a spindle-celled sarcoma. Radium was applied in the open wound, and no recurrence occurred until 1924, when the patient returned with pain in the chest, loss of weight, and cough. At this time four rapidly growing tumors appeared in her scalp, which on removal proved to be fibrosarcomata. The wounds were treated with radium and healed within two months; but roentgenograms of the right lung showed a shadow clouding the entire upper lobe and two small round tumor shadows in the lower lobe.

literature ranged from twenty-five to forty years and the disease is much more frequent than generally believed. Of 136 cases in the literature there were sixty-seven reported in Germany and thirty-six in Italy. The disease is always of traumatic origin, and usually there is a slight traumatism, often quite negligible. As for the origin of the pathological formation the viewpoints differ; some believe it is of periostitic origin, others think that it originates in the connective tissue.

The subjective symptoms are pain and functional impairment; objective symptoms are swelling and sometimes hydrarthrosis, rarely hemarthrosis of the knee. The condition is mostly unilateral; bilateral involvement is rare. The course differs; in some cases improvement occurs in eight days while in others the severity increases, giving a permanent disability in many cases. The treatment consists of immobilization with compressive bandages, plaster is not necessary. Complete immobilization of from ten to fifteen days with the use of hot air is sufficient; then careful walking exercises are instituted. In protracted cases diathermy, infra-red ray, hot air, etc. may be used.—*A. Steindler, M.D., Iowa City, Iowa.*

FRACTURES AND DISLOCATIONS OF THE TARSUS: AN ANALYSIS OF A SERIES OF 109 CASES. A. R. Shands, Jr. *Southern Med. J.*, XXIV, 1019, Dec. 1931.

This is a statistical report from the examination of the roentgenograms taken at the Emergency Hospital at Washington, D. C., over a period of four years. In a total of 1,069 injuries of the foot, there were 744 showing evidence of fracture or dislocation. Fractures of the ankle mortice and each separate bone are separately classified and percentages given. The fracture of the os calcis was the most frequent (48.7 per cent.). There were nineteen dislocations in this series.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

ACUTE VERTEBRAL FRACTURES WITHOUT CORD INJURY. H. Earle Cornwell. *Southern Med. J.*, XXV, 141, Feb. 1932.

A series of 315 back injuries is discussed.

The following conclusions are made:

First aid is proper splinting, careful handling, treatment of shock. Better transfer face down.

Early and thorough physical and x-ray examination, especially a good lateral view.

Suspect fracture in every case of pain in the back following trauma.

A negative x-ray is not always conclusive.

Collapse of vertebra may occur even with good treatment.

Complete reduction is desired, but good function may be obtained without it.

Always treat patient first, fracture second.

Excellent functional results frequently occur after severe comminuted fractures.

Physiological fusion of vertebrae is to be desired and frequently occurs.

Operative fusion is occasionally indicated.

Hibbs' spinal fusion is preferred by the author.

Osteo-arthritis is a common complication in patients over forty years of age.

More than one fractured vertebra is sometimes seen at different levels.

The majority of back injuries are associated with other injuries.

Manipulative reduction under anaesthesia in anterior compression fractures is rarely indicated.

This type is usually reduced by gradual hyperextension on a frame, with or without traction. A body plaster cast may be used following reduction.

Cervical fractures require special treatment.

A period of twelve weeks is usually necessary for bed treatment and wearing a brace is necessary when ambulatory. A description of an excellent and simple bed hyperextension frame is described in detail. Also the proper method of applying body casts.

Fractures of the spine in the aged or very slight fractures can be treated by a few weeks' rest in bed with boards under the mattress.

Too early weight-bearing, sitting, or walking should be avoided.

Collapse of the body of the vertebra in cases which were properly treated is due to interference with the blood supply at the time of the injury.

Supports should not be removed until the fracture is firmly healed. Supports should not be worn too long on account of muscle wasting and a mental disability.

The psychological treatment of these cases is important.

This is a very clear, concise, and logical résumé of the care of back injuries.—*F. G. Hodgson, M.D., Atlanta, Georgia.*

Massive Bone Grafts: Report of Cases. Oscar L. Miller. *Southern Med. J.*, XXV, 211, Mar. 1932.

The general principles of bone grafting are discussed. A massive bone graft taken from the tibia, reenforced by osteo-periosteal particles is preferred by the author. Nine cases are reported in detail with excellent roentgenograms showing preoperative and post-operative results.—*F. G. Hodgson, M.D., Atlanta, Georgia.*

Plaster Cast, Bone Pin Method in Fractures of the Lower Leg. J. Warren White. *Southern Med. J.*, XXV, 218, Mar. 1932.

This is a modified method for treating difficult fractures of the leg by direct skeletal traction and fixation with bone pins and plaster. The method has been simplified and no expensive apparatus is required.

A modified "Yankee" drill is used to place modified bicycle spokes above and below the fracture. A modified horseshoe is used to put traction on the pins. After reduction is obtained, a modified plumber's pipe plug is used to fix the pins in the plaster-of-Paris. This seems to be a practical and inexpensive method of using direct skeletal traction and fixation.—*F. G. Hodgson, M.D., Atlanta, Georgia.*

Bucket-Handle or Loop Fracture of Internal Semilunar Cartilage of the Knee Joint. M. S. Henderson. *Surg. Clin. North America*, XI, 731, 1931.

Three patients are presented, all women. In each, a diagnosis of bucket-handle type of fracture was made, sustained by operation, with early recovery. The author believes that a little thickening at the anterior attachment of the internal cartilage and a lack of total extension of the knee should suggest this type of semilunar cartilage injury. A history of trauma followed by disability and usually by swelling is almost a necessity. Lastly, attacks when due to bucket-handle type of fractures are more prolonged and create more disturbance than when a pedicle flap is the cause of the derangement.—*W. H. Hamsa, M.D., Iowa City, Iowa.*

Open Treatment of Fractures. Wm. Darrach *Surg. Clin. North America*, XI, 577, 1931.

The author makes the following indications which should be complied with before making an open reduction.

1. That a satisfactory reduction cannot be obtained and maintained by more conservative methods.

2. That the expected result will be sufficiently better than that hoped for by closed methods to warrant the additional risk.

3. That the patient presents no other contra-indications to operation.

4. That the operator has at his command the technique, equipment, and skill required for work.

Asepsis is emphasized.—*T. H. Vinke, M.D., Iowa City, Iowa.*

Osteitis Fibrosa Cystica. T. A. Shallow. *Surg. Clin. North America*, XI, 1327, Dec. 1931.

The author presents two cases of hyperparathyroidism. The first was a white female, twenty-nine years old, with numerous fractures, all occurring following the slightest trauma; blood calcium of thirteen and ninety-five hundredths milligrams per

0 cubic centimeters, and blood phosphorous of three and two-tenths milligrams per 100 bic centimeters. Following parathyroidectomy and removal of a thyroid adenoma, e fractures healed and the blood calcium and phosphorous values dropped to nine and ır-tenths and two and eight-tenths, respectively. Histologic study revealed adenoıtous thyroid growth and normal parathyroid tissue.

The second case was a white boy, twelve years old, with a markedly shortened leg ve inches) and a history of a slight fall one year previously. X-ray examination owed extensive cystic changes in the ilium and both femora with marked angulation of e femur of the shorter leg, with associated bone atrophy. Blood calcium and phosorous values were ten and eleven-hundredths and five and fifty-two hundredths lligrams, respectively. Considering this an arrested case of hyperparathyroidism, the tient was dismissed with support only.—*W. H. Hamsa, M.D., Iowa City, Iowa.*

ALIGNANT CHANGES OCCURRING IN BENIGN GIANT CELL TUMORS OF BONE. Channing C. Simmons. *Surg., Gynec. Obstet.*, LIII, 469, Oct. 1931.

This is an analysis of the giant-cell tumors of bone in the Registry of Bone Sarcoma evious to 1925. An end-result study is thereby presented of cases treated and ob-rved over a five-year period. There was a total of 116 cases. The femur, tibia, dius, and jaws were the most frequently involved bones; the conclusions are as follows:

1. Amputation cures 100 per cent. of giant-cell tumor, and the same may be exted of resection or complete excision.

2. Curetting cures sixty-three per cent.; combined with radiation, seventy-three r cent.

3. Radiation alone cures seventy-five per cent.

4. Coley's serum (seven cases) cured forty-two per cent.

5. Of those conservatively treated, seven and five-tenths per cent. died presumly of metastases. In three cases where microscopic comparative examinations could made, the character of the lesions had changed from benign to malignant.

6. There is no proved case of death from metastasis, although the above premptive data is almost incontestable.

7. The type of giant-cell tumor, microscopically, apparently has little relation to e prognosis.—*J. Kulowski, M.D., Iowa City, Iowa.*

'STIC DEVELOPMENT IN THE SEMILUNAR CARTILAGES. E. S. J. King. *Surg., Gynec., Obstet.*, LIII, 606, Nov. 1931.

The author draws the conclusion from evidence presented that cysts of the semiıar cartilages are comparable in development to ganglia. There is an exaggeration of ıormal secretory function of synovial cells. He refutes the congenital and lymphaticgin hypotheses. Normal and pathological joint and cyst histology are discussed. ıe article is well illustrated with photomicrographs.—*Richard McGovney, M.D., Los ıgeles, California.*

TEOCHONDROMATOSIS OF THE KNEE JOINT. Paul C. Colonna. *Surg., Gynec. Obstet.* LIII, 698, Nov. 1931.

The author reviews the historical development of our knowledge of osteochondroıtosis and discusses four cases in the knee.

Two main types are found (1) multiple loose bodies, (2) a diffuse type resembling a oplastic process. Mechanical blocking is the most constant symptom, and the roentıogram is the deciding diagnostic factor.

The treatment is surgical; removal of the loose bodies in type 1 and synovectomy in pe 2.

The article is illustrated with roentgenograms, photographs of the gross appearance, d photomicrographs.—*Richard McGovney, M.D., Los Angeles, California.*

THE THERMAL EFFECT OF DIATHERMY IN THE TREATMENT OF JOINTS. G. Edström. *Svenska Läk.-tidning.*, XXVIII, 865, June 1931.

The author has treated by diathermy the knee joints on living horses, and registered the intra-articular temperature; the experimental series comprises six cases. At a current of three-tenths amperes no difference in the temperature could be observed; at five-tenths amperes there was after about five minutes a rise of temperature of one degree, centigrade, inside the joint; at seven-tenths amperes the rise of temperature amounted to two to three degrees after five minutes, the rise after fifteen to twenty-five minutes amounting to four to five degrees. At a current of one ampere, burns rapidly occurred in the skin. The subcutaneous temperature was taken simultaneously by a special thermometer and was found to be four-tenths to one degree lower than inside the joint. The author adheres to Simons' theory,—*i.e.*, that the diathermal effect is occasioned by resistance heat, whereas the dielectric heat component is of subordinate importance.—*Harald Nilsonne, M.D., Stockholm, Sweden.*

ON THE QUESTION OF LUMBAGO TRAUMATICA ON THE BASIS OF MATERIAL FROM THE STATE ACCIDENT INSURANCE. H. Nilsonne. *Svenska Läk.-tidning.*, XXVIII, 1257, 1931.

The author has perused the reports of 354 cases of lumbago reported to the State Accident Insurance as accidents during work. The material comprises injuries reported as lumbago, sprains, muscular ruptures, contusion, etc., of the back. Sprains in the gluteal region are included, as this region is functionally included in the lumbosacral group. The material of investigation does not include any case of skeletal injury.

Out of these 354 cases, 249 were primarily accecpted and 105 primarily refused. Of the latter, twenty-six appealed with the result that the Insurance Council altered the decision in six cases.

Seventy-three and nine-tenths per cent. of the cases gave up work on the day of the accident, sixteen and nine-tenths per cent. on the first or second day afterwards, and nine and two-tenths per cent. only on the third day after the accident or later. Three-fourths of the cases of the group of lumbago thus interrupted their work immediately and, therefore, in this respect satisfy the claims from a technical insurance point of view. Most of the cases were of young persons. By adding together separately the cases above and below the age of forty-five, these groups are found to be proportioned as four to one. One would expect instead to find these injuries to occur more frequently in older workmen, in whom one has to reckon with a worn-out back, spondylitis deformans, etc. This fact seems to be against a so called rheumatic lumbago entering into the material to any great extent. The proportion of females to males is one to seventeen. The corresponding figure for all cases of injuries reported to the State Accident Insurance is one to fifteen. In no case has invalidity followed, recurrence in one only. The duration of the sick period in cases taken at random has amounted to an average of twenty-four and three-tenths days.

The conclusions to be drawn from this statistical investigation are that traumatic lumbago does not materially differ from other groups of injuries, so far as its technical insurance character is concerned. Both with regard to interruption of work, age, and frequency of recurrence, it is largely equivalent with other injuries sustained by accident. In the author's opinion, therefore, the individual case should not be considered differently, from the point of view of medical insurance, than other accidental injuries, just because there is something called lumbago rheumatica.

The following are the lines along which the author wishes these injuries to be judged:

(1). The back should have been exposed to some accident or to some event resembling an accident, at which, through something unforeseen, a sudden, severe strain has been made on the back muscles.

(2). This accident should lead to immediate or almost immediate interruption of work.

(3). The effect of the accident should be some objectively demonstrable, functional disturbance of the back.

(4). There should be a logical and biological connection between this functional disturbance and the reported nature of the accident.

Ewing's Sarcoma. W. B. Carrell. *Texas State J. Med.*, XXVII, 588, Dec. 1931.

Ewing believes that the round-cell type of sarcoma which bears his name must primarily have its cell origin in the perivascular tissue and not in the vascular endothelium, and therefore should be differentiated from the angio-endothelioma. The tumor grows and displaces bone in an expansile manner, resulting in a mass in the soft tissue after perforating the periosteum. The tumor is cellular throughout and does not produce bone as does osteogenic sarcoma.

A typical case report is cited. Ewing's sarcoma is especially interesting from the standpoint of differential diagnosis. It most frequently is confused with osteomyelitis and osteogenic sarcoma. It differs from osteomyelitis on the following points:

1. No sequestra are present.
2. Sarcoma is found most frequently in the middle of the shaft while osteomyelitis is almost always found in the end of the bone.
3. Periosteum in sarcoma is more regular and not fragmented as it is in osteomyelitis.

The x-ray differs from osteogenic sarcoma in that:

1. Ewing's sarcoma appears in the middle instead of at the end of the shaft and has a more destructive lesion.
2. Ewing's sarcoma grows by expansion and gives a mottled appearance to the bone.

Treatment:

In early tumor, give heavy doses of x-ray therapy and then completely remove by excision, or amputation, followed by x-ray therapy over a long period of time. In case of metastasis use x-ray or radium therapy alone without amputation.

Prognosis:

The average duration of life is longer than that in osteogenic sarcoma, but reported cures are few and most die of metastasis to skin or viscera.—*C. W. Gilfillan, M.D., Iowa City, Iowa.*

Osteitis Cystica Fibrosa. James W. Nixon. *Texas State J. Med.*, XXVII, 591, Dec. 1931.

There are certain peculiar characteristics of osteitis fibrosa cystica which aid in the diagnosis and recognition of this condition.

Osteitis fibrosa cystica is a cystic disease of bone. Chronic in type, it occurs before the twentieth year of life, this being thought to be due to some disturbance of bone structure; but it more recently has been thought to be due to a disturbance of endocrine origin, particularly hyperparathyroidism. The theory that has recently been enjoying the greatest favor is that of hyperparathyroidism, a case having been known to improve rapidly after removal of parathyroids, and the high calcium content of the blood returned to normal.

Osteitis fibrosa cystica must be differentiated from:

1. Rickets
2. Osteogenic sarcoma
3. Osteomalacia
4. Bone abscess
5. Paget's disease.

Operation is often necessary. Incision should be made through soft parts down to cyst and then the cyst wall crushed. Small portion of shell should be removed and contents examined. The walls of the cyst should be fractured and wound closed without drainage. In doubtful cases, Bloodgood has advised curettement and swabbing out cyst with fifty per cent. zinc sulphate solution.—*C. W. Gilfillan, M.D., Iowa City, Iowa.*

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The Journal of Bone and Joint Surgery

THE CORRELATION OF EXPERIMENTAL STREPTOCOCCIC ARTHRITIS IN RABBITS WITH CHRONIC RHEUMATOID ARTHRITIS *

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NEW YORK, N. Y.

PART I

CLINICAL AND PATHOLOGICAL STUDY OF EXPERIMENTAL ARTHRITIS

The specific relationship of streptococci to the type of joint disease commonly designated as atrophic-deformans has been strongly emphasized by recent research. Clinicians have for many years rightfully suspected an infectious origin, and the metastatic dissemination of bacteria from distant foci of infection—such as teeth and tonsils—has been more and more generally recognized.

Experimental proof of bacterial causation was not generally accepted, because in the past most of the joint lesions produced were of pyogenic nature and not of the serous, productive type found in the human. Differentiation and use of the less virulent streptococci—such as alpha prime, certain viridans, and indifferent forms—eliminated this pus-forming tendency in joint lesions in rabbits, and the experimental arthritis thus produced was of indolent type.

Recent improvements in blood-culture technique have simplified the isolation and culture of streptococci of low virulence in cases of afebrile chronic arthritis; and in our series of more than a thousand cases, at least ten different types of streptococci were isolated from the blood stream of subacute or chronic arthritics. The majority of these strains have been inoculated into rabbits and mice. A series of thirty-eight rabbits have been inoculated in this experimental work with a control in each case. Of the types used, the mannite fermenters, hemolytic as well as viridans,

* From the Pathological Laboratories of Beth Israel Hospital, New York, at [illegible] Laboratory, 6 East Seventy-eighth Street, New York.

were the most constantly arthrotropic and produced approximately, if not exactly, the same lesions that are found in the arthritic joints of humans.

The technique employed was the intravenous injection of daily doses of one cubic centimeter of a twenty-four-hour broth culture for four consecutive days. The course of events subsequent to the last injection can be summarized under the following three clinical stages:

Stage of Septicaemia.—Duration was usually two to four days. The symptoms were those of a generalized infection with fever, loss of appetite and weight, and at times a concomitant diarrhoea. During this stage, blood cultures were one hundred per cent. positive for the injected streptococcus.

Stage of Selective Localization.—Beginning with the fourth day, there was a gradual return to normal health. Blood cultures were negative in the great majority of cases.

Stage of Acute, Subacute, and Chronic Arthropathies.—The earliest manifestation of joint localization could be elicited the second or third week. An acute onset was common with infrequens strains of hemolytic streptococci, while viridans and indifferent forms produced characteristic subacute and chronic arthropathies. An involved joint usually became progressively worse with a general course of remissions or intermissions, but a very small percentage (under ten per cent.) showed complete spontaneous recovery.

It was rare to find the infective organisms on examination of direct smears of joint exudate but, by culture, positive findings were increased to about fifty per cent. We had no difficulty at any time in culturally demonstrating the presence of the injected micro-organisms in joint scrapings.

PATHOLOGY OF THE EXPERIMENTAL JOINT INFECTIONS

The intelligible exposition of joint pathology caused by hematogenous infection demands a working knowledge of the blood supply of articulations. In the diarthroses the blood supply from the terminal tributaries of the deep vessels is from two separate channels:

(a). The medullary vessels entering the nutrient foramina supply the bone and bone-marrow. Both epiphysis and diaphysis have individual branches which terminate in the neighborhood of the epiphyseal cartilage. Cartilage itself is devoid of direct blood supply and there is no anastomosis between these terminal branches until adult life, when the cartilage is absorbed in the process of epiphyseal-diaphyseal union.

(b). Synovial vessels supply the joint capsule and the synovial sheaths, anastomosing with the terminal branches of the periosteo-perichondrial tributaries (Fig. 1).

Since the progressive pathological changes are directly related to the histological stage of development in a joint, we are confining our observations to the relatively young joints in which union of the epiphysis and

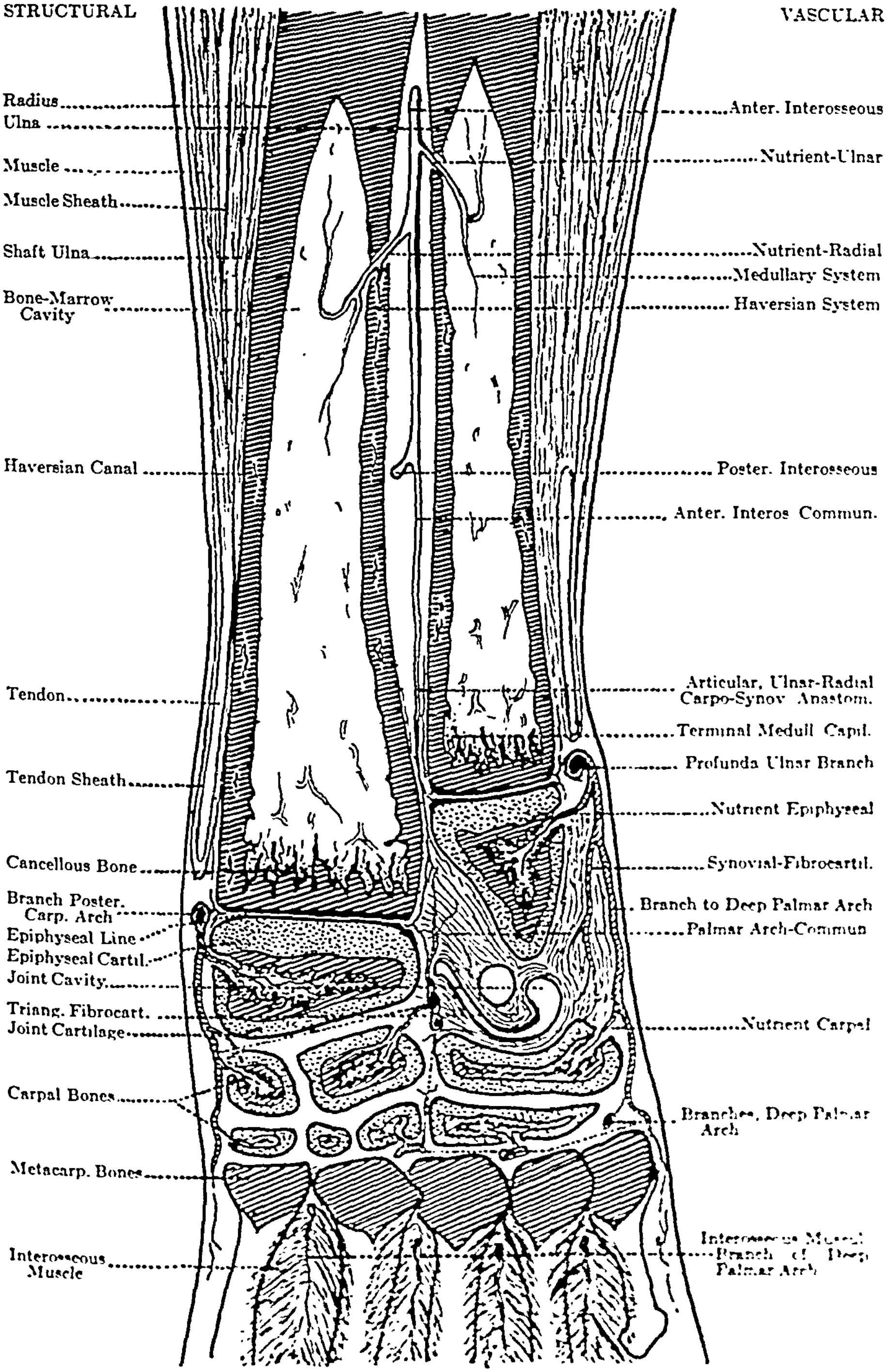

FIG. I

Diagrammatic presentation of a rabbit's wrist joint. The vascular supply is described at the right-hand side. The left-hand side deals with the various structures that make up the joint.

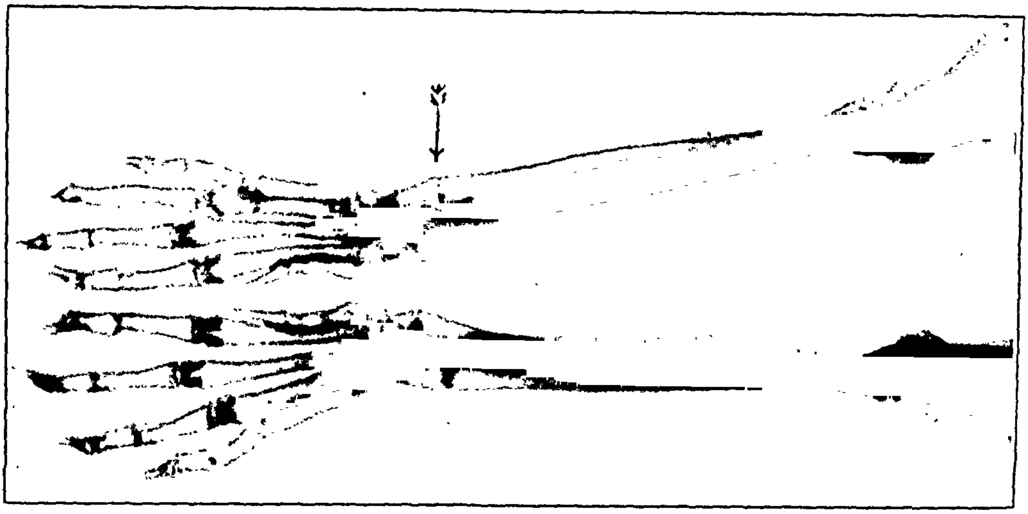

Fig. 2

Roentgenogram of a normal wrist joint. The arrow points to the epiphyseal line and the epiphyseal cartilage.

diaphysis has not been completed. Three stages are definitely distinguishable:

The Pre-Exudative Stage

The duration is usually from a week to a month. During this interval selective localization of the infective agent has taken place through the medullary blood supply in its terminal branches. Clinical evidence of any synovial infiltration is still lacking.

The roentgenogram of a normal joint before the complete union of the epiphysis shows a uniformly clear straight line with a relatively narrow band of epiphyseal cartilage below it (Fig. 2). With the onset of localization of the arthritic lesion the epiphyseal line becomes distorted, and

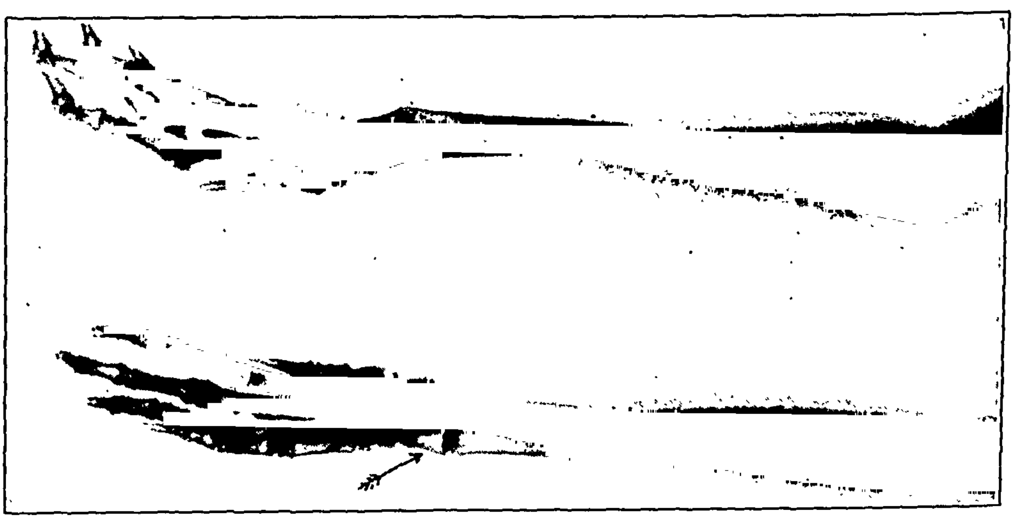

Fig. 3

The earliest signs of a localizing infection in the epiphyseo-diaphyseal region of the lower end of the ulna. The epiphyseal line is broken at its center by a well defined circumscribed lesion. External to it, there is a diffuse infiltration involving the lateral aspect of the diaphysis of the radius.

Fig. 4-A

Fig. 4-B

Focal infection in the bone marrow of the ulnar epiphysis.

A low-power view of a localizing chronic infection with a central area of necrosis surrounded by a dense zone of infiltration.

A higher magnification of same, showing part of the central necrotic area and the round-cell infiltration at its periphery.

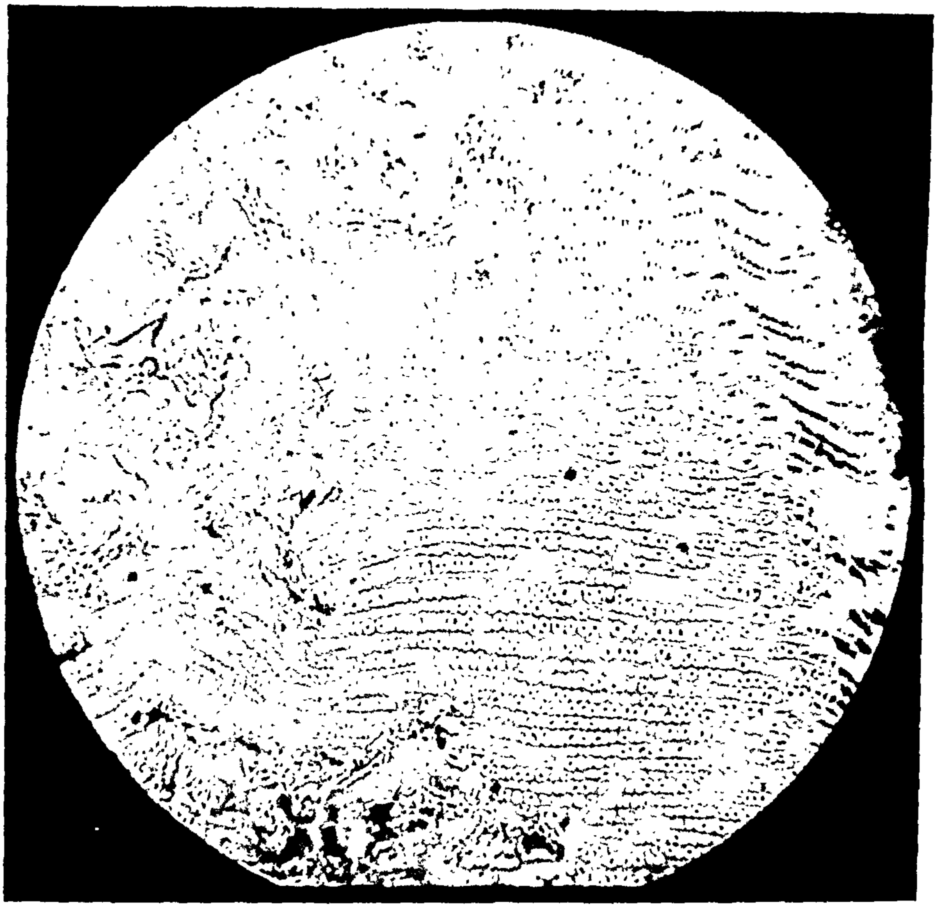

FIG. 5

Diffuse opacities along the epiphyseal line and epiphyseal cartilage. Buds of proliferating vascular and osteoblastic tissues invading the epiphyseal cartilage. The cartilage is also abnormally active with complete loss of its normal boundaries.

clearly circumscribed or diffusely scattered, hazy opacities appear in its course (Fig. 3). Microscopically these circumscribed opacities show various stages of the early stigmata of a localizing chronic infection. There is a central area of degeneration, which may go to complete necrosis, and a periphery of marked round-cell infiltration, mainly lymphocytic, but interspersed with connective-tissue cells (Figs. 4-A and 4-B).

The diffuse opacities are buds of proliferating vascular and osteoblastic tissue invading the epiphyseal cartilage. The cartilage itself likewise undergoes proliferative changes. Columns that in quiescence would contain two to four cartilage cells show anywhere from ten to forty (Fig. 5). The outlines of the cartilage are broken down and the pathological picture simulates that of rachitis (Figs. 6-A and 6-B).

Changes concurrent with the second or exudative stage gradually supervene and the rachitic picture changes to a true exudation.

The Exudative Stage

This period is especially characterized by inflammatory changes limited to the soft tissues of the joint, chiefly the synovial membrane and its

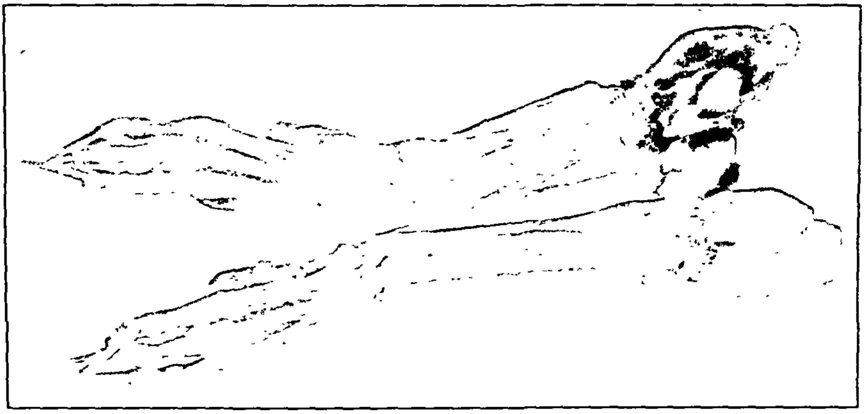

FIG. 6-A

Extreme changes in a prolonged pre-exudative stage simulating rachitis.
A photograph of the wrist joints of a rabbit, the microscopic picture of which is shown in Fig. 5.

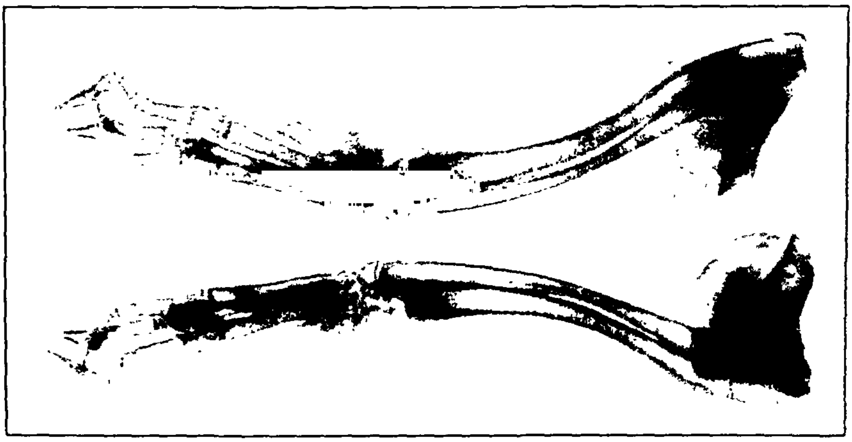

FIG. 6-B

The roentgenogram of the same wrists showing practically no exudate, but sufficient enlargement of the joint boundaries, with a relative osteoporosis and marked bowing of both ulna and radius.

appendages: the perichondrium, the periostium, and the synovial sheaths of tendons and muscles. These inflammatory processes develop independently of the structural bony changes just described, because the hematogenous origin of the infection carries it by a separate blood supply to the synovia.

The onset of exudation though synchronous with the pre-exudative stage is ordinarily insidious and passes unnoticed until sufficient fluid is present to be discernible or demonstrable by x-ray. Onsets of an acute nature are not at all uncommon with strains of hemolytic streptococci that are arthrotropic. Sometimes there is single joint involvement, such as an acute interphalangeal exudation (Figs. 7-A and 7-B). More fre-

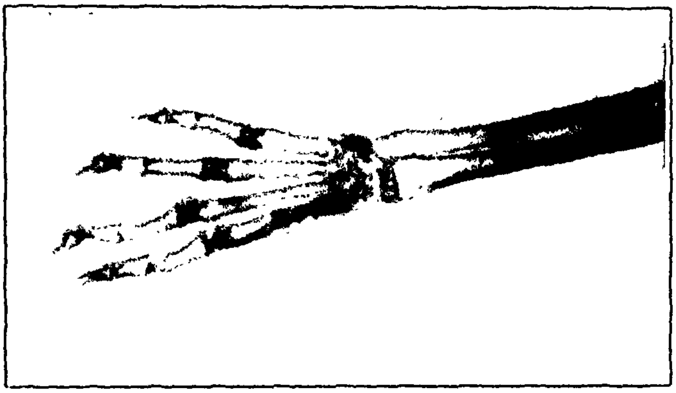

FIG. 7-A

Acute exudative inflammation of the metacarpo-phalangeal joint of the index digit.

FIG. 7-B

Photograph of the animal in Fig. 7-A, protecting the involved extremity.

quently one or both wrists are affected (Fig. 8); less frequently an ankle (Fig. 9). Viridans strains nearly always give an exudative stage of insidious onset.

The clinical signs of exudation—such as local heat, redness, swelling, tenderness, stiffness, and pain on active and passive motion of the affected joints—are so familiar that a lengthy discussion of them is not required.

Under the influence of the inflammatory process the synovial lining secretes more fluid than the normal joint cavity would contain. The character of the fluid depends on the nature and intensity of the inflammation. It may vary from a clear, mucinous, straw-colored fluid with only a few mononuclear cells to a thick, grumous exudate with numerous desquamated synovial and mononuclear cells. Leucocytes may be present. There is usually abundant mucous and fibrin. Occasionally the fluid may even be hemorrhagic.

The key to the pathological interpretation of the exudative signs is found in the abnormal hyperaemia of the synovial stroma (Figs. 10-A and 10-B). The effects are: first an active, then a passive congestion, and finally an overgrowth of the endothelial lining of the capillaries which gradually leads to an ischaemia. This ischaemia is the essential characteristic that in its course of successive intermissions and remissions, tending steadily to chronicity, gradually prepares the ground for the third or final stage.

Stage of Alternate Regeneration and Degeneration

The signs and symptoms of the preceding stages gradually blend together and become more intensified, while the disease runs its progressively active course. The duration is indefinite. It may terminate in either spontaneous recovery or be cut short by treatment. In either case, one may still find more or less permanent stigmata of tissue changes from infection. The usual course, however, is that of simultaneous regenerative and degenerative reactions influenced by the histological nature of the involved tissues. Therefore, it is pertinent in

the analysis of the related pathological studies to follow a definite plan based on histogenesis.

CHANGES INVOLVING THE BONE-MARROW

Normally the structure of bone-marrow depends on age. In young animals it is a highly vascular-cellular structure in a thin network of reticular connective tissue (Fig. 11). With advance of life, the cellular element is replaced gradually by fat.

The earliest changes in an infected marrow have already been dealt with under the former stages (Figs. 4-A and 4-B). The subsequent changes are mostly of a degenerative nature, involving all types of marrow cells,—*viz.*, the erythrocytic and leucocytic hemopoietic system. The connective-tissue reticulum reverts to active proliferation in an attempt

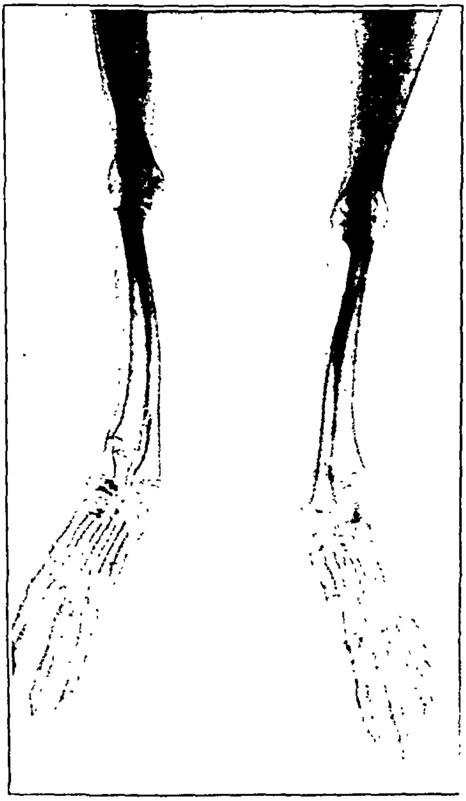

FIG. 8

Acute exudative inflammation involving both wrist joints. The above is a typical picture of the acute stage of an exudative atrophic-deformans infection that may occur in the human subject. In addition to the exudation, note the characteristic bone and cartilage pathology and the marked ulnar-deviation deformity.

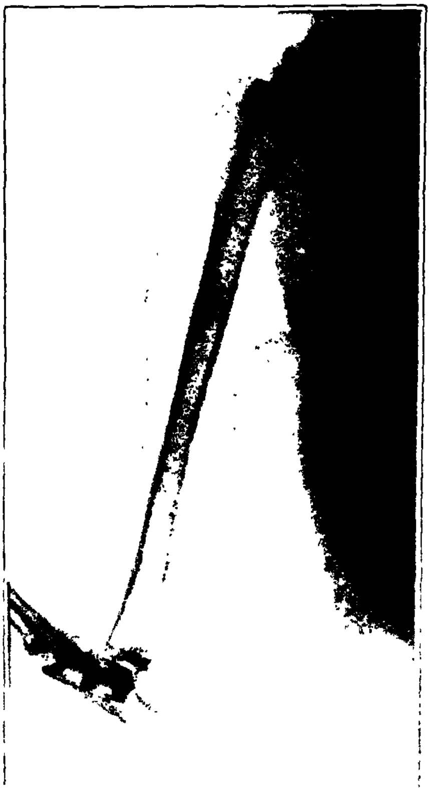

FIG. 9

Acute exudative inflammation of the ankle. Advanced stage of an exudative atrophic-deformans lesion of the ankle joint with marked exudation and signs of complete atrophy of the [illegible]

Fig. 10-A

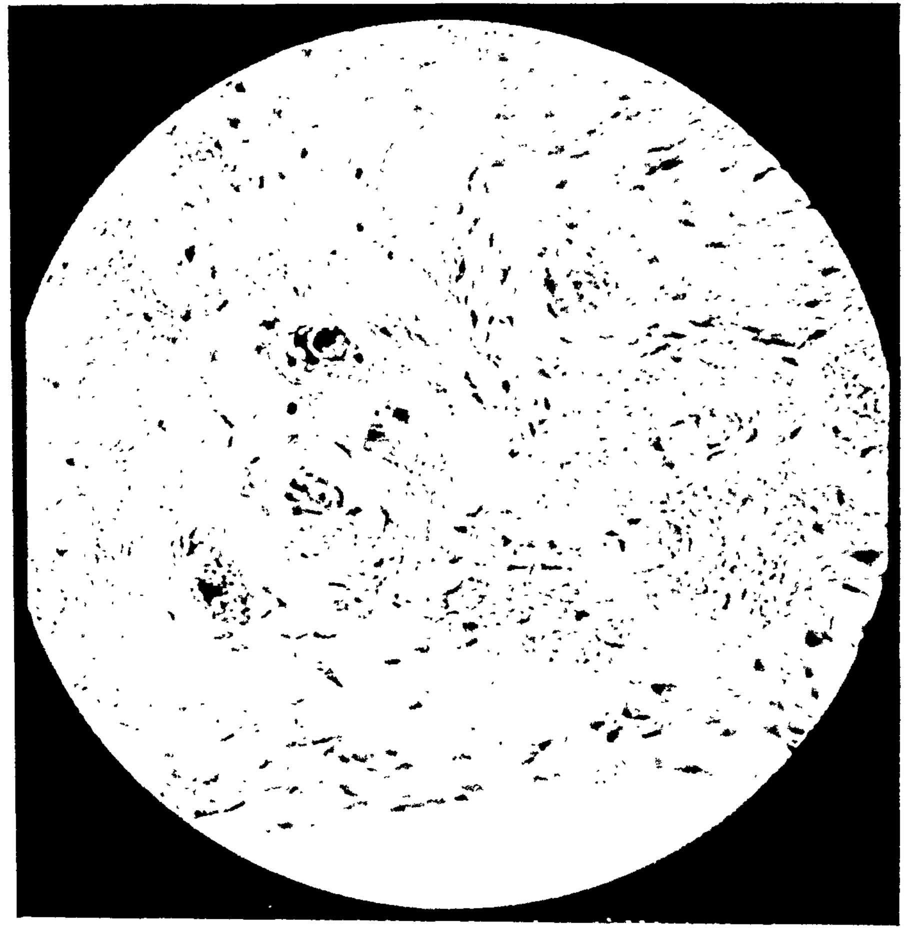

Fig. 10-B

Abnormal vascularization of the synovial stroma.

In the centre of the picture there is a thick synovial villus projecting into the joint cavity. The stroma of this villous overgrowth is abnormally vascular.

The endothelial lining of the synovial blood vessels is found in a stage of active proliferation, thereby interfering with the circulation of the tissues.

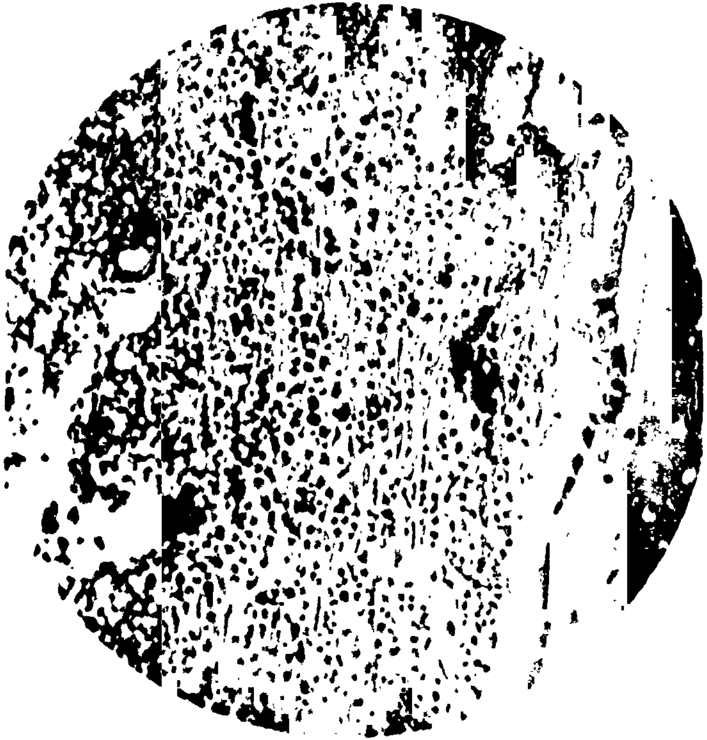

Fig. 11

Normal bone-marrow of young rabbit. Part of the shaft of bone with its osteoblastic layer is seen at the right of the picture. The rest is bone-marrow of normal consistency. Compare with Fig. 12

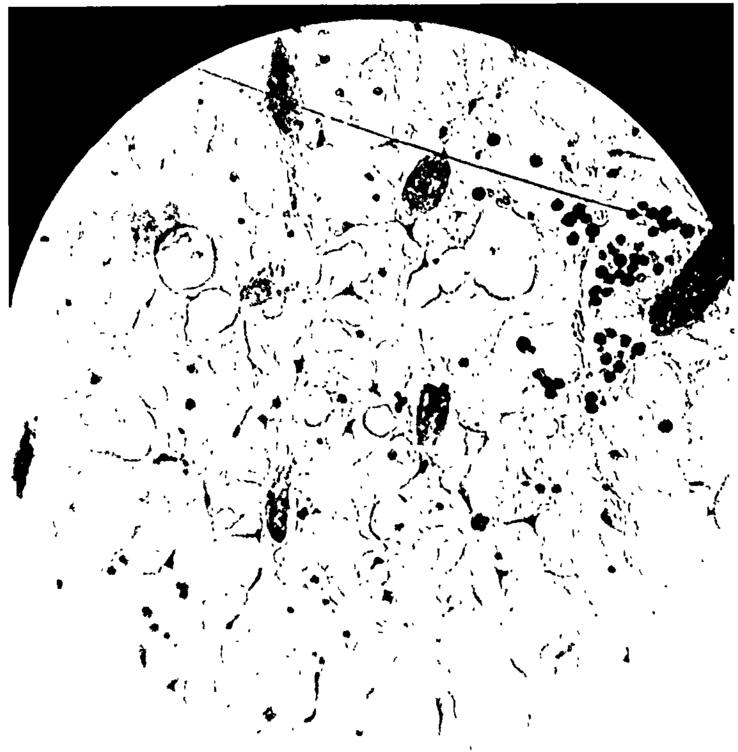

Fig. 12

Bone-marrow in an advanced atrophic-deformans infection. The reticular connective tissue has taken the place of the fast disappearing hemopoietic cells, a small group of which can still be seen at one side of the picture. Note the marked contrast between this picture and Fig. 11.

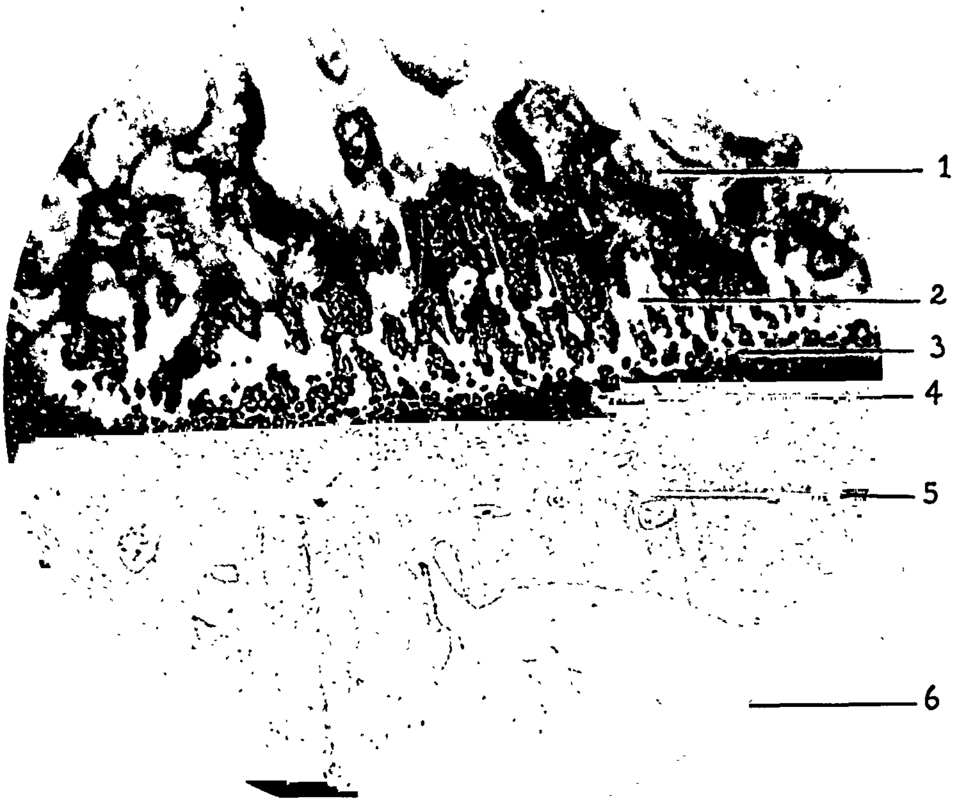

FIG. 13

Osteoblastic activity in the region of cancellous bone.
1. Cancellous bone trabeculae in diaphysis undergoing decalcification.
2. Osteogenetic layer with marked calcium infiltration.
3. Invasion of the epiphyseal line by osteogenetic tissue.
4. Islands of new bone in epiphyseal cartilage.
5. Epiphyseal bone.
6. Epiphyseal bone-marrow having undergone fatty degeneration.

to replace the fast disappearing marrow cells. Similarly there is an increase in fat cells. In other words, we observe a premature aging of the bone-marrow with a marked shrinkage of the vascular supply (Fig. 12).

CHANGES IN BONE

In the region of cancellous bone and the endosteum of the shafts, the osteogenetic tissues, under the influence of infection, are spurred to abnormal activity. As a result new bone trabeculae are seen interlacing in the marrow spaces, and there is a thickening of the shaft. At the same time, bands of osteoblastic buds with their increased vascular supply invade the epiphyseal cartilage and deposit small islands of bone in its matrix (Fig. 13). These changes, however, are not of a permanent nature, as an equally abnormal activity of the osteoclasts supervenes and absorbs: first, most of the newly formed bone (except in the cartilage) and, later, both new and old calcification, this giving rise to a relative

FIG. 14-A

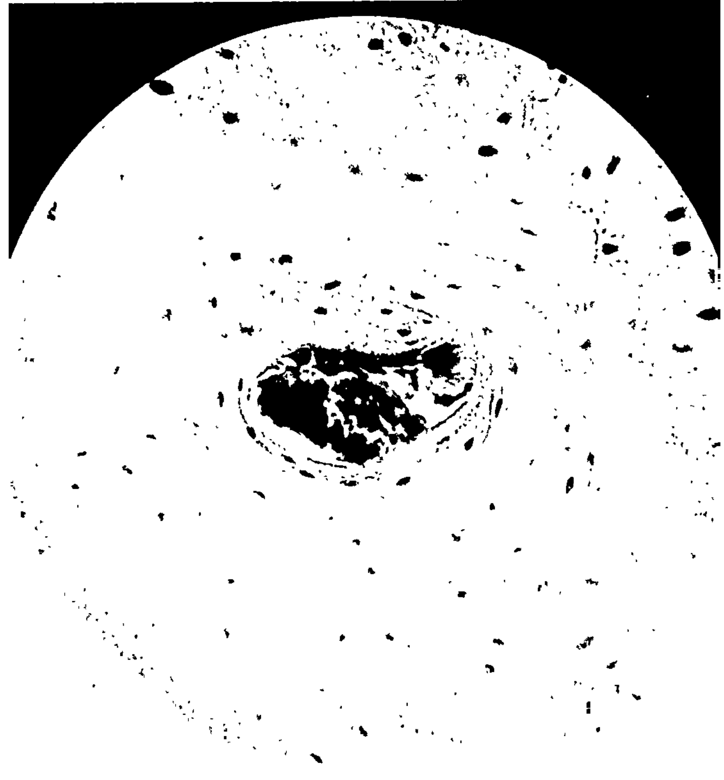

FIG. 14-B

Bone pathology resulting from vascular changes in the haversian system.

The arrows in the epiphysis point to occluded haversian canals. The bone at this area has undergone degenerative changes of a necrotic nature, as is clearly outlined in the slide by its dark bluish color.

A high-power view of one of these occluded haversian canals. The entire cavity is filled with a structureless necrotic tissue. No trace of vascular structure can be seen.

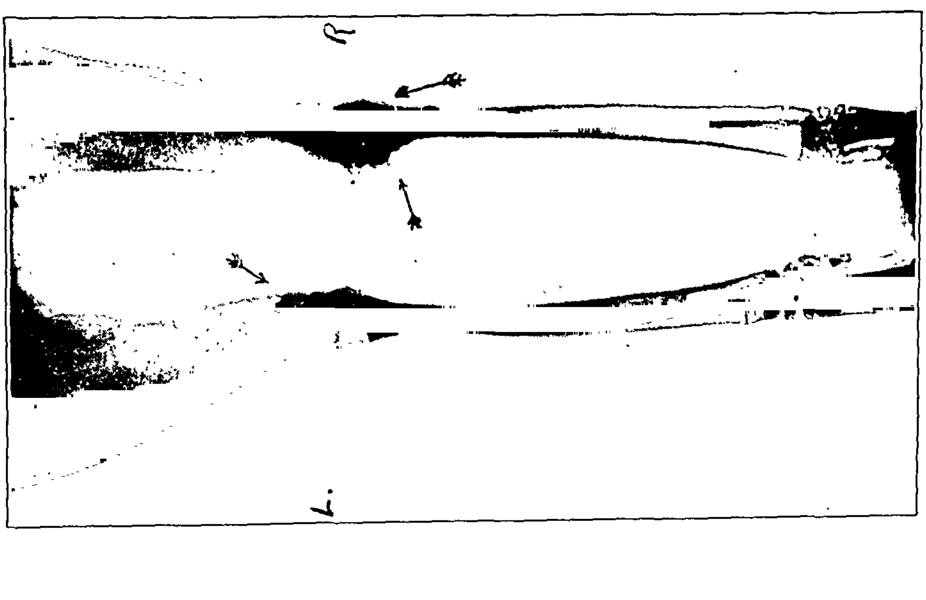

FIG. 15

Productive bony changes characteristic of osteo-arthritic lesions. The arrows point to osteophytic extensions projecting from the olecranon and coronoid processes into the soft tissues of the elbow.

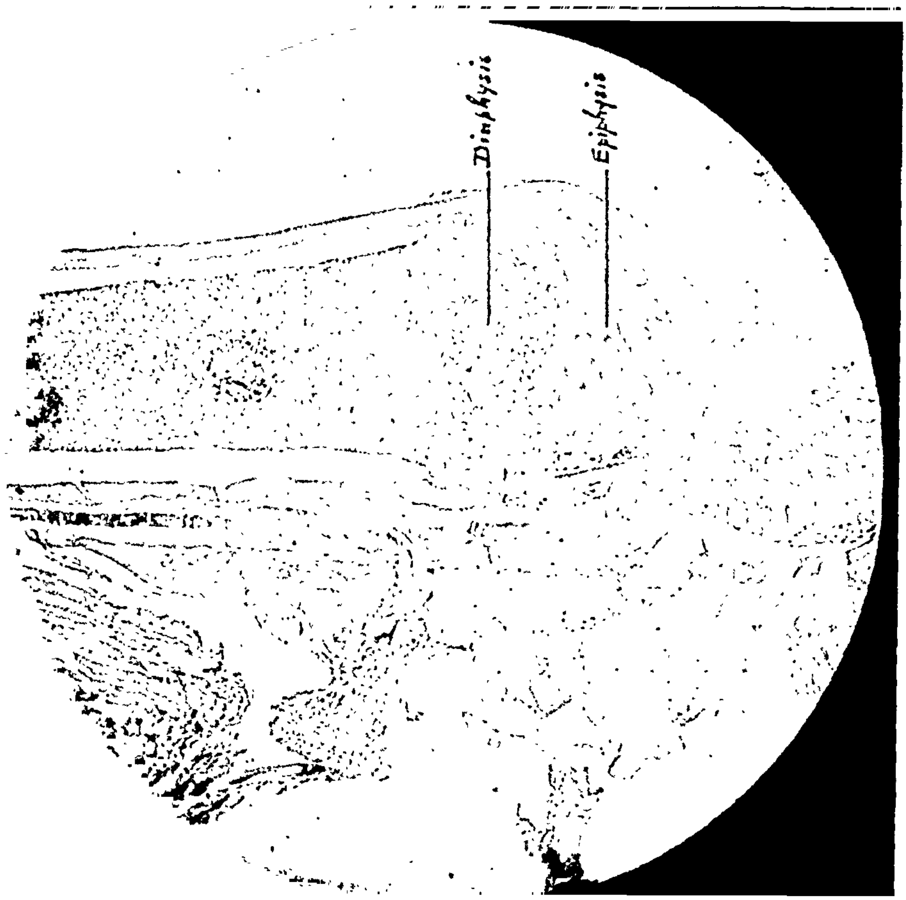

FIG. 16

Complete bony union between epiphysis and diaphysis with disappearance of the epiphyseal cartilage.

FIG. 17

Changes in cartilage.

1. Area of liquefaction necrosis with the normal boundaries of cartilage still visible.
2. A bud of connective tissue growing into the necrotic area.
3. Connective-tissue replacement of denuded joint cartilage, resulting in an indentation of the joint surface.

osteoporosis. Further changes in the epiphyseal cartilage will be considered later.

So far all the regenerative and degenerative changes in the bone tissues are but phases of an exaggerated physiological activity with the difference that what age would ultimately do over a period of years, the infection accomplishes in weeks or months. This again is a premature aging as in the case of the bone-marrow changes.

The real degenerative changes in bone are primarily of vascular origin. In the areas supplied by the final tributaries of the haversian system, especially at the ends of long bones, we may occasionally discover occluded vessels of the size of arterioles or capillaries. More commonly we see a marked narrowing of their lumen due to endothelial proliferation. The bone adjacent to these areas loses its normal texture, and becomes basophilic. The lamellar markings become more prominent, but later are completely lost during the process of decalcification (Figs. 14-A and 14-B). Whether a collateral circulation would eventually be set up could not be determined.

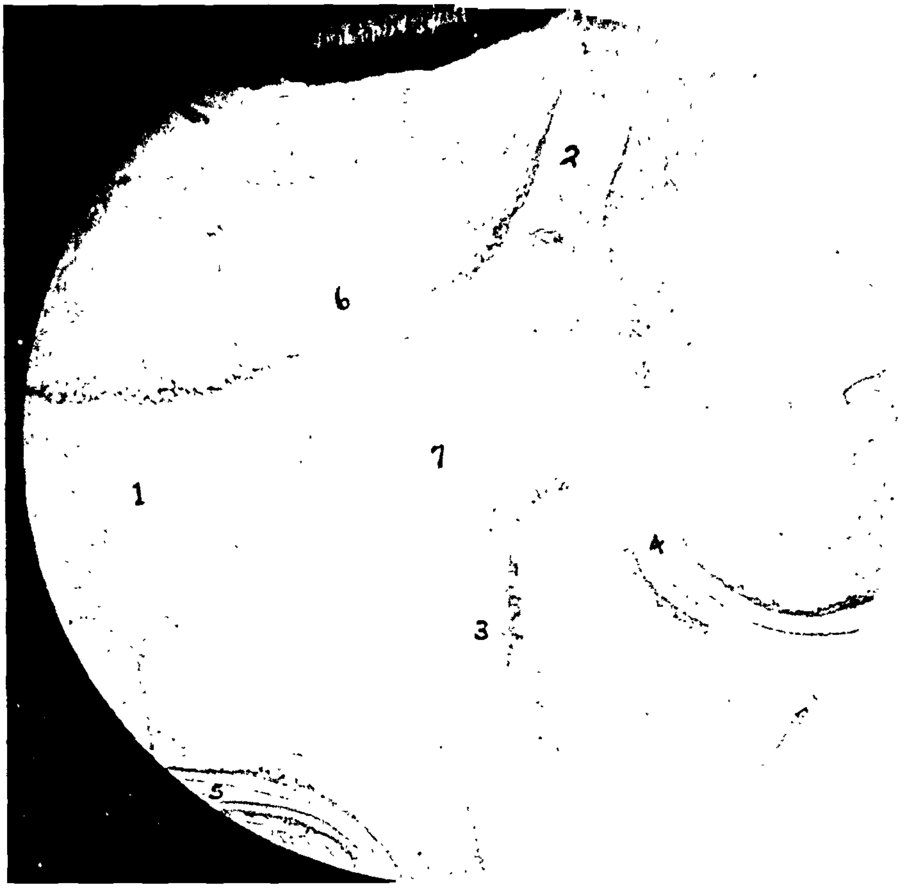

FIG. 18

Fibrous ankylosis.

1 and *2*. Fibrous ankylosis between epiphysis and the carpal bones.
3. Pannusitis of the hyaline cartilage of one of the carpal bones.
4 and *5*. Normal joint surfaces.
6. Destruction of epiphyseal cartilage, exposure of bone, filling of the gap with synovial connective tissue.
7. Joint cavity partly obliterated by villous proliferation of synovial tissue and loose bodies.

Productive changes of bone, characteristic of osteo-arthritic lesions,—such as lipping of joint surface, bony overgrowth into the joint cavity, or spicules in soft tissues—and the deformity and discomfort accompanying them, are not common in this type of infection. Nevertheless, they occur at certain stages of the disease and occasionally persist indefinitely (Fig. 15).

CHANGES IN CARTILAGE

The epiphyseal cartilage that has previously been invaded by the medullary osteoblastic buds undergoes a gradual shrinking in size and eventually is replaced by new bone. The result is a complete bony union between epiphysis and diaphysis (Fig. 16).

The changes in the joint cartilage are of a different nature: The destruction of cartilage, so common in infected joints, is the end result of a chain of preceding changes, which in order of occurrence are:

(1). A liquefaction necrosis, where one can still see the outline of the cartilage but no matrix and cells (Fig. 17).
(2). Invasion of this liquefaction area by connective-tissue cells and new blood vessels.
(3). A moderate contraction of the invaded connective tissue, resulting in an indentation of the joint surface (Fig. 17).

Usually, in a pathological joint, there is sufficient synovial fluid to prevent friction. This connective tissue may persist, or may eventually undergo ossification unless certain other factors supervene:

(a). If such an area is close to the synovial membrane and adjacent to a similarly involved joint surface, fibrous union may take place (Fig. 18).
(b). If, for any reason, the synovial fluid decreases sufficiently to cause friction in these denuded areas, every active and passive

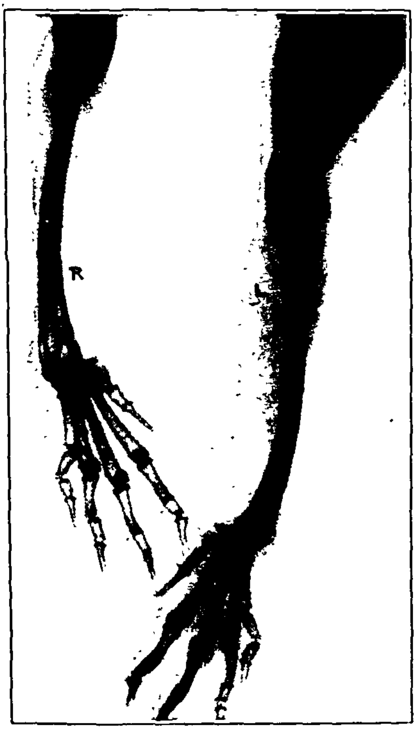

Fig. 19

Generalized oedema of the extremities. In addition to the extensive atrophic-deformans pathology of both wrists, there is a generalized oedema of the soft tissues extending well above both elbow joints.

Fig. 20

Radial deviation and flexion deformity. Roentgenogram of an extreme case of atrophic-deformans infection showing marked destruction of carpal bones of both wrists. The ankylosis in the right wrist is fibrous; in the left, both fibrous and bony. The resulting deformity is typical of the radial-deviation kind. (See also Fig. 19.) For the ulnar-deviation type of deformity, see Figs. 8 and 6-A.

motion becomes painful. A *progressive form of this stage* may lead to complete destruction of joint cartilage, exposure of bone, and finally eburnation.

Bony exposure and eburnation, however, rarely take place because there is usually sufficient fluid present, and extreme sensitiveness on motion serves to protect against undue friction. It occurs more commonly in relatively less painful joints of the osteo-arthritic, hypertrophic type.

CHANGES IN SYNOVIAL TISSUES

The earlier changes in the synovial sac and its appendages have been discussed. Subsequent changes depend on the anatomical relationship of the synovial sac with other joint tissues. We have, therefore:

(a). *Synovial-tissue changes in relation to the joint cavity:* During the exudative stage, the joint cavity has already been enlarged by the abnormal accumulation of fluid, due to the simultaneous working of two factors: firstly, an abnormal hyperaemia of the synovial sac; secondly, and of greater moment, the direct activity of the synovial cells. If this activity is not arrested naturally, it gives rise to villous outgrowths into the joint cavity. It is possible for some of these villi to become detached from their pedicles and lie free in the cavity as loose bodies (Fig. 18). Usually, however, the pedicle is broad enough and contains sufficient blood supply to grow unhampered and almost fill the joint space (Fig. 16, also Fig. 14-A).

(b). *Changes of the joint capsule proper:* In addition to the proliferation of the synovial lining we notice a thickening of the synovial stroma. The increased vascularization gives it a spongy texture with a dense network of connective-tissue fibers (Fig. 10-A). With the gradual advent of endarterial changes, the joint capsule becomes relatively ischaemic, but its contour is not altered thereby, due to its heavy connective-tissue reticulum. There can also be complete fibrosis of the synovial tissues.

(c). *Synovial-tissue changes in relation to cartilage and bone:* The joint cartilage, near the attachment of the capsule is now covered by a thin membrane, the pannus (Fig. 18) which, at first structureless, is soon infiltrated by fibrous tissue from the synovialis which may give rise to localized fibrous ankylosis. The bone is not directly involved in relation to the synovial membrane unless there is sufficient cartilage destruction to result in exposure of the bone. If this occurs, and it is relatively uncommon, the pathological changes are similar to those found in the case of cartilage destruction (Fig. 18). New bone formation in synovial tissues may originate possibly from a reversion of fibroblastic to osteoblastic cells. It is, however, not common in this type of infection.

(d). *Synovial tissue changes in relation to periosteum, tendon, and muscle sheaths:* Anatomically, the periosteum, the tendon, and muscle sheaths are continuations of the joint capsule. During the course of development, although their continuity is lost, they are still contiguous tissues of the same histological structure. Consequently, it is natural

FIG. 21-A

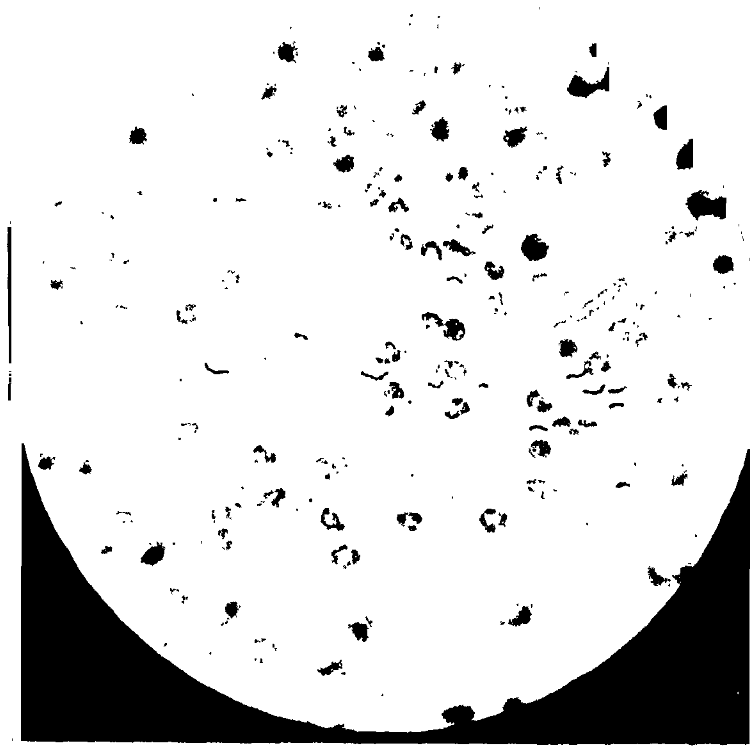

FIG. 21-B

Dissemination of streptococci in synovial fluid.

Direct smear of synovial fluid stained with the Gram method.

Smear of synovial fluid after subjecting the joint to the special culture method without breaking the synovial capsule.

to expect changes of a similar nature when infection occurs in these tissues.

The periosteum is thickened and may even revert to its osteoblastic property. At the attachment of the tendons there is an abnormal proliferation of tendon cells. The tendon sheaths are also moderately swollen, and contain more fluid than normally. The same process may extend to the muscle sheaths. Finally, a localized oedema of the soft tissues may occur (Fig. 19). Groups of large muscles may undergo gradual atrophy of disuse. With improvement in the joints and more liberal use, they may gradually recover their tonus and nourishment. The atrophic changes in the group of small muscles, like the abductors and adductors of fingers and toes or the digital interossei, are usually of a more permanent character. The vascular supply of the interossei is from the same source as that of the joint proper; consequently, when extensive endarterial changes exist in these terminal branches, their blood supply is seriously interfered with. This fact and the hematogenous distribution of infection in close proximity to the joint may be contributing factors to the early atrophy, so commonly encountered in these muscles. A peculiar characteristic of these atrophic changes is that these muscles are usually involved in groups according to their anatomical position and function, abductors are more commonly involved than adductors, and flexors more than extensors, this giving rise to the commonly encountered abduction and flexion deformities (Figs. 19 and 20, also Figs. 8 and 6-A).

SUMMARY AND DISCUSSION

It has been possible by injecting certain mannite-fermenting arthrotropic streptococci, isolated from the blood stream of afebrile arthritic patients, to produce in rabbits pathological lesions exactly comparable to those found in chronic arthritis in the human being.

This fact has also been substantiated by the almost complete similarity of the morbid anatomy of our streptococcic arthritic joints in rabbits to those naturally acquired in the human subject, and so carefully investigated and described by Nichols and Richardson, Llewellyn and Jones, Strangeway, Knaggs, and others.

Most of this morbid anatomy and the concomitant symptoms we were able to trace directly or indirectly to changes in capillary circulation, a finding which Pemberton upholds and ascribes to some toxic degeneration, either associated with or merely followed by disturbed metabolism.

Since toxic degeneration in capillaries is a common finding in the course of chronic disease, and because of the recent revival of the hypothesis that the changes of atrophic rheumatoid arthritis are toxic anaphylactic manifestations (Swift, Boots), we felt that the direct effect of infection on joints should first be definitely excluded before theorizing on the basis of indirect factors. In acute inflammatory conditions of a pyogenic nature, the demonstration of the causative micro-organism in diseased tissues is usually taken as a sufficient evidence of the direct ac-

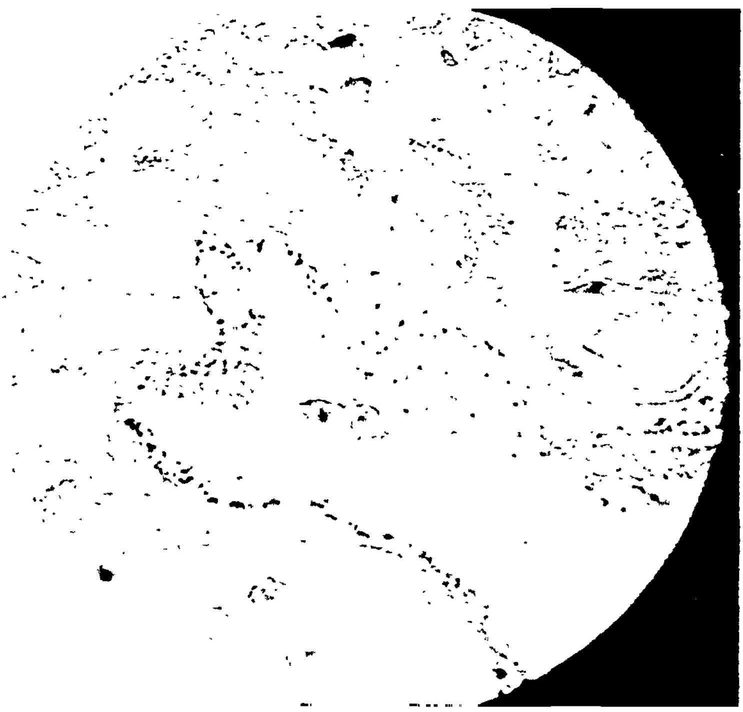

Fig. 22-A

Dissemination of diplococci in the synovial lining and subsynovial tissue.

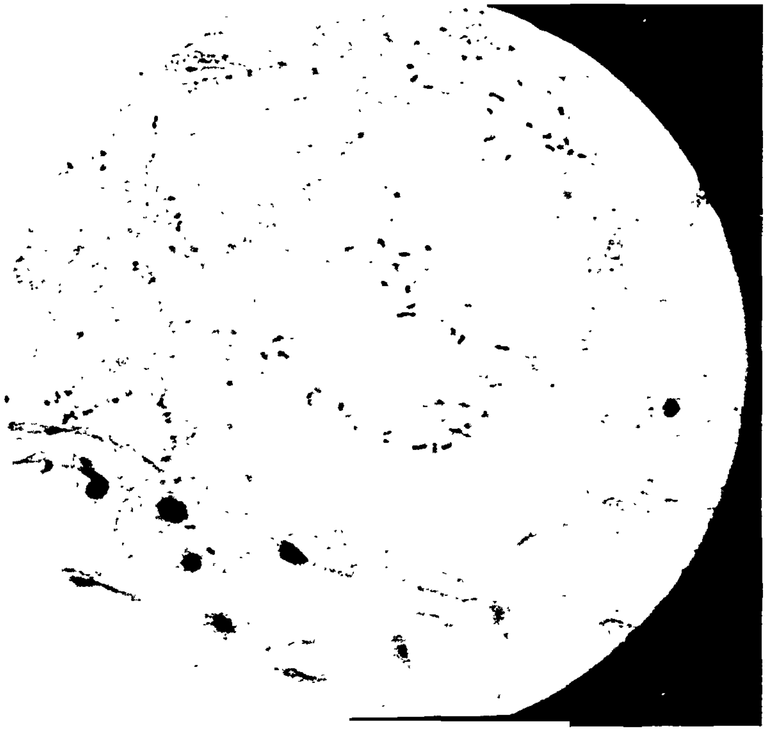

Fig. 22-B

Dissemination of diplococci in the synovial stroma.

Demonstration of streptococci in synovial tissue.

tivity of the invading germ (the demonstration of gonococcus in gonorrhoeal arthritis or of staphylococcus in carbuncles). Changes in remote tissues or organs from which the presence of bacteria is excluded may be considered indirect degenerative alteration of a toxic or allergic nature.

We felt it necessary to exhaust all possible means of demonstrating the dissemination of streptococci in diseased tissues of our experimental animals before we ascribed such changes as were present to indirect causes such as toxaemia or allergy.

PART II

THE RÔLE OF STREPTOCOCCUS IN THE PATHOGENESIS OF JOINT LESIONS

The toxic or allergic theory of the pathogenesis of chronic rheumatoid arthritis owes its existence to the inconsistency of the cultural findings and the totally unsuccessful attempts to demonstrate the presence of bacteria in tissue sections.

The similarity of arthritis as produced in rabbits to that naturally acquired by the human subject, coupled with the fact that we never failed to isolate the injected streptococcus from cultures of scrapings from the affected joints, compelled a thorough revision of our investigation of this subject.

Our early attempts to demonstrate streptococci in tissue sections were uniformly unsuccessful. Various methods of tissue-fixing and bacteria-staining were resorted to, but all we could find were pleomorphic gram-positive granules, occurring singly or at times in pairs, in the neighborhood of the epiphyseal line and in close proximity to the terminal medullary capillaries.

The regularity of these findings developed in us a conviction that these gram-positive granules might be involution forms of streptococci. If they were viable, by culturing such tissues, their true morphology could be restored. The following technique was used:*

Animals with definite arthritic lesions were killed by stunning. After shaving off the hair, the skin of the extremities was carefully removed, and the infected joint severed *in toto*, leaving about a quarter of an inch of bone both above and below the joint. The dissection was performed under sterile precautions, and with the least manipulation and injury possible. The entire severed articulation was then placed in neutral bouillon containing two per cent. peptone and incubated for from three to six days, depending on the thickness of the tissues. It was then washed in sterile saline and fixed in formalin. For decalcifying we used a mixture of equal parts of saturated (eighty-five per cent.) formic acid and twenty per cent. solution of sodium citrate. Of all the bacterial stains the Gram

* This technique was used by Dr. Eugen Frankel in Hamburg for demonstration of typhoid bacilli in roseola.

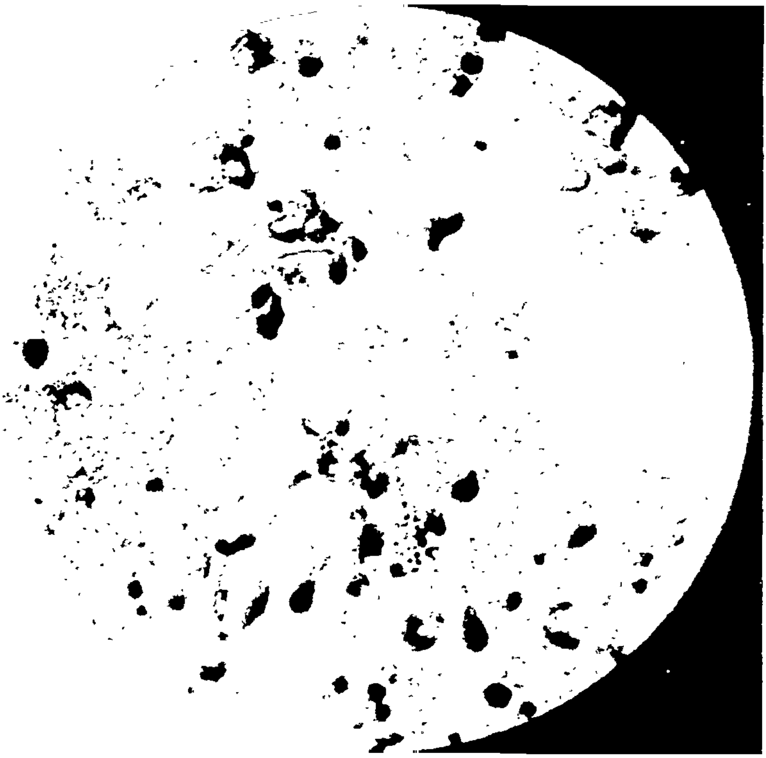

FIG. 23

Demonstration of streptococci in bone-marrow. The above picture is the high magnification (oil) of Figs. 4-A and 4-B. In the zone of lymphocytic infiltration there are seen streptococci in single and diplococcic forms.

method was the best as a differential stain, while the methyl-green pyronin proved superior for demonstration purposes.

Carrying out the above technique under strictly aseptic precautions was not an easy task. With all due care, cultures were at times contaminated by saprophytic bacilli or staphylococcus albus. Although this is highly undesirable, the experimental results are little affected by their presence. Staphylococci, being non-motile, will never penetrate into the tissues of the joint proper. Their presence on the surface or immediately under it need not be taken into consideration. Bacillus subtilis, on the other hand, being actively motile, can penetrate into any part of the joint by following the blood and lymph channels. Fortunately, however, it can scarcely be mistaken for streptococcus on account of its size and clear-cut morphology. Normal joints were also incubated in bouillon cultures of streptococcus, staphylococcus, and bacillus subtilis, and although all these types of micro-organisms could be demonstrated on the surface of tissue, only the motile bacillus penetrated the tissue parenchyma.

As the analysis of the pathogenesis of focal lesions of hematogenous origin requires an adequate knowledge of the regional blood supply, the

Fig. 24

Demonstration of streptococci in the haversian system. The arrow points to a haversian system tributary in the loose connective tissue of which diplococci were found.

Fig. 25

Demonstration of streptococci in cartilage. The joint surface of hyaline cartilage is covered with a thin membrane which is densely infiltrated with diplococci.

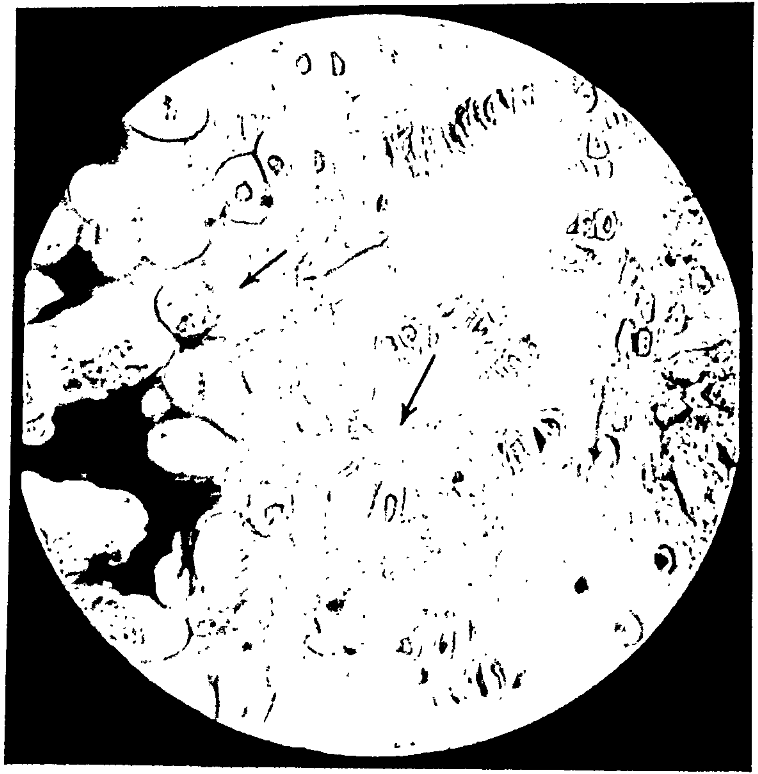

FIG. 26-A

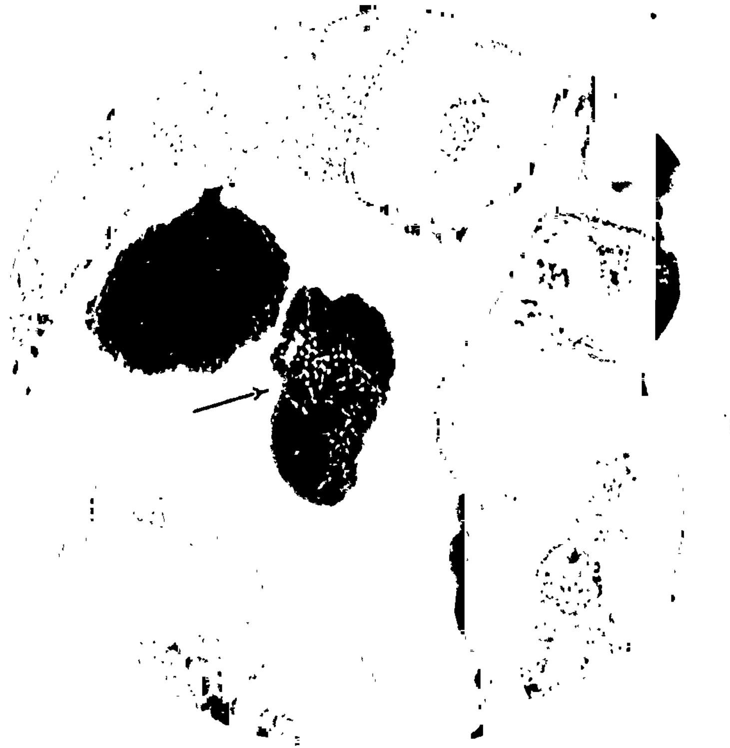

FIG. 26-B

Demonstration of streptococci in degenerated cartilage cells.

High-power magnification (dry) of epiphyseal cartilage, showing invasion of osteoblastic tissue. The cartilage cells of the invaded area have lost their nuclei and their protoplasm has become granular.

High-power magnification (oil) of Fig. 26-A, showing streptococcic infiltration of degenerated cartilage cells.

investigation of blood-carried microbic dissemination should follow an identical course. Of the tissues that make up the joint, the bone and synovial sac have each an independent blood supply. The cartilage is the only tissue that has no direct arterial contribution; but it is located close to terminal branches of vessels of the bone and bone-marrow, both proximally and distally, and to the synovial vessels laterally (Consult Figure 1).

In demonstrating the streptococcic dissemination in joints we will take the vascular tissues first and leave the avascular cartilage until the last.

DISSEMINATION OF STREPTOCOCCI IN SYNOVIAL TISSUES

The demonstration of streptococci in synovial fluids without resorting to cultural procedures is difficult, but they can be demonstrated occasionally during the acute phase of the disease (Fig. 21-A), especially when the fluid is slightly hemorrhagic. When synovial fluid is subjected to the culturing method *in situ* as described above, demonstration becomes relatively easy (Fig. 21-B). The true morphology of the streptococcus in such fluid media as the synovial exudate is strikingly characteristic, — chains of four to eight or more can be demonstrated easily.

The next site where streptococci can be found in abundant growth is the inner synovial layer (Fig. 22-A). Here, however, they occur mostly in diplococcic forms and occasionally in chains of three or four.

In the stroma of the synovial sac, the streptococci invade the proliferating connective-tissue fibers and they are situated for the most part under the lining (Fig. 22-B). The blood vessels are invariably free from streptococci, although they are originally the channels through which dissemination takes place. We attribute this to the bactericidal property of the blood. Were it not for this power, a persistent septicaemia would ensue. The cause of intermittent septicaemias, usually of an abortive nature, will be explained in discussion of the involvement of internal organs.

DISSEMINATION OF STREPTOCOCCI IN BONE

The nutrient vessels supply the bone-marrow and through the haversian system the bone proper. The bone-marrow is usually free from bacteria because of the phagocytic property of its cellular elements. In the case, however, of focal infections occurring in the marrow, streptococci can be demonstrated at the periphery of the central necrotic area in the zone of round-cell infiltration (Fig. 23 and Figs. 4-A and 4-B).

Bone tissue proper is impervious to streptococci. The microbic dissemination takes place through the haversian system and can be carried to its terminal branchings. For reasons already given, streptococci could not be demonstrated in the lumen of blood vessels; but in the loose connective-tissue framework of the smaller and terminal haversian canals, streptococci in diplococcic forms could be occasionally demonstrated as shown in Figure 24.

Fig. 27

Demonstration of streptococci in tendons. Streptococci invading the tendon as indicated by the arrow.

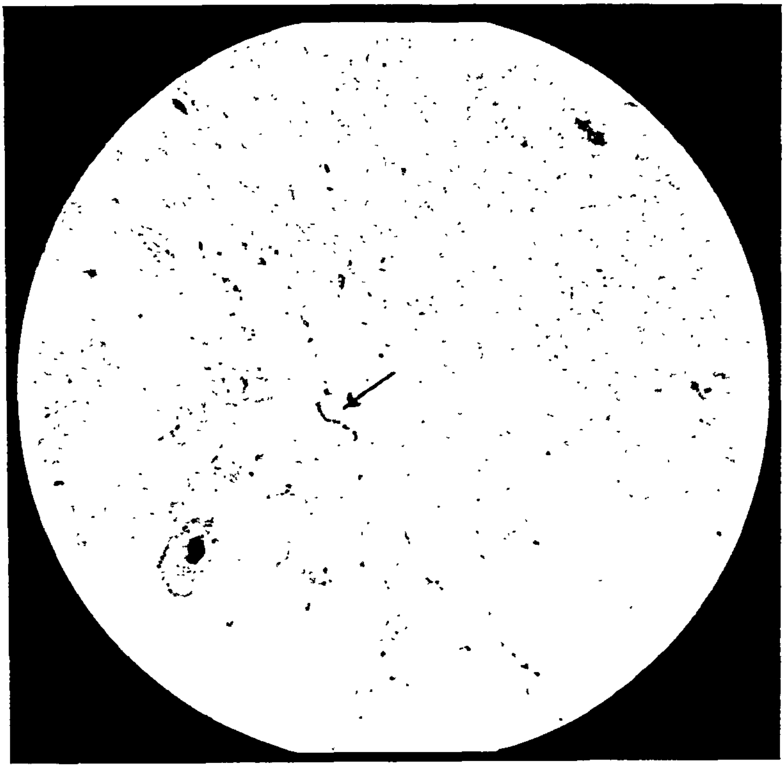

Fig. 28

Demonstration of streptococci in the interlobular connective tissue of liver.

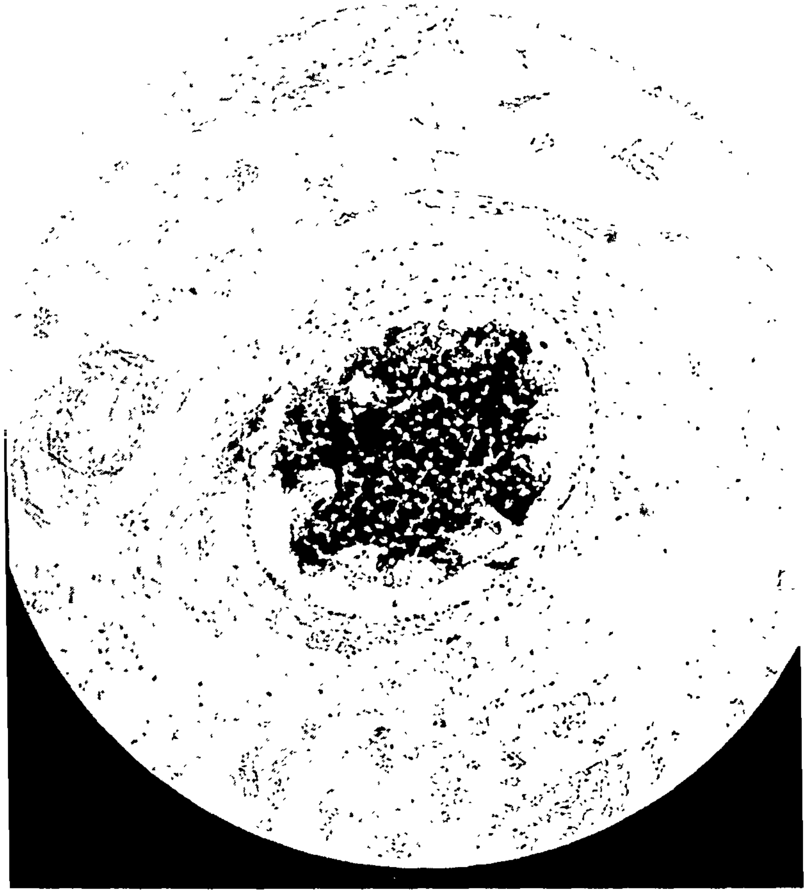

FIG. 29-A

FIG. 29-B

Demonstration of streptococci in hepatic vessels.

Low-power magnification of a thrombus-like mass in a liver vessel, probably the portal vein.

Under high magnification (oil) the thrombus-like mass is made of a collection of bacteria, diplococci.

We think that during the period of artificial incubation, this bacterial mass originated from a diplococcus imbedded in the endothelial lining of the portal vein. We never encountered a similar picture in tissues that were not subjected to a previous culturing.

DISSEMINATION OF STREPTOCOCCI IN CARTILAGE

An avascular tissue such as cartilage should be among the least vulnerable to the direct effect of a hematogenous infection; consequently the toxic or allergic hypothesis of causation in arthritis should find definite test of its validity in the nature of cartilage pathology.

If it is possible for streptococci to invade cartilage in hematogenous infection, the nearest approach is from the periphery of this avascular tissue towards the center. The boundaries of an epiphyseal cartilage are the joint cavity, the epiphyseal cancellous bone, and the diaphyseal cancellous bone.

In dealing with the pathology we have already called attention to the inflamed pannus on the joint surface of cartilage. Under higher magnification, this pannus tissue is seen to be infiltrated with diplococci, similar in form to the streptococci which infiltrate the synovial membrane (Fig. 25).

The pathological changes in epiphyseal cartilage were described as a process of osteoblastic invasion of its matrix (Fig. 13). The buds of proliferating and highly vascular osteogenetic tissue invade the cartilage columns, destroy the cartilage cells, and simultaneously vascularize the invaded area, thereby carrying infection to it (Fig. 26-A). The high magnification of Figure 26-A shows streptococci in the invaded and partly destroyed cartilage cells. This infectious process may gradually involve a large part or the whole of the cartilage, and replace it by either bone or cancellous tissue as is shown in Figure 26-B.

SUMMARY AND CONCLUSIONS

By incubating the whole joint we were able to demonstrate these infecting organisms in practically all lesions associated with chronic atrophic arthropathies. Streptococci were found in every part of the synovial tissues where pathological changes could be detected. No streptococci could be demonstrated in compact bone, yet the spread of infection in bone tissue could be traced step by step through its medullary and haversian vascular supply. In the avascular cartilage the spread of streptococci was through infected bone tissue and synovial infiltration. Normal joints were subjected to the same procedure with uniformly negative findings.

To complete the picture of infection, we have recently studied the tendons and muscles in the immediate neighborhood of arthritic joints. We had no difficulty in demonstrating streptococci in tendons at the zone of nuclear proliferation (Fig. 27). Muscles were extensively infiltrated with streptococci at their sheaths, but in spite of great care the possibility of outside contamination in surface areas must be considered.

Throughout this study the progress of the disease could always be traced directly to the terminal blood vessels, as is true in all infections of hematogenous origin. Despite the specific selectivity of the arthrotropic streptococci used in these experiments, internal organs, especially

the liver and kidneys, were not exempt from pathological changes of toxic nature involving their parenchyma. Nevertheless, streptococci could be demonstrated in the interlobular connective tissue of the liver (Fig. 28), and occasionally even in the hepatic vessels (Figs. 29-A and 29-B). This finding is highly significant in that it forcibly brings home the fact that chronic rheumatoid arthritis is fundamentally a systemic disease, and it explains the transient septicaemias that occur intermittently in the course of the infection.

PATHOLOGICAL FRACTURES IN OSTEOMYELITIS*

BY NORMAN CAPENER, F.R.C.S., EXETER, ENGLAND
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A series of pathological fractures in patients suffering from chronic osteomyelitis, seen by us at the University Hospital, has caused us to investigate the frequency, cause, prevention, and treatment of this quite serious complication. At first sight it appeared a somewhat commonplace subject, but we were surprised to find an extreme paucity of references to it in the literature. Most writers deal with it very cursorily and the following quotation is typical of many of the statements in textbooks: "Pathological fractures are not uncommon, especially if proper precautions are not taken". Desiring to know what these precautions should be and believing that the errors in treatment were probably of commission as well as omission, we have prepared the following report based upon a study of 1068 cases of osteomyelitis, seen in this Clinic during the past five years.

Almost all cases of pathological fracture in osteomyelitis are due to preventable causes. Delayed recognition of the disease or inadequate treatment in the early, acute stage are very important factors, for both may be responsible for massive diaphyseal sequestration. And here it may be stated that every case in which there is sequestration involving the whole circumference of the diaphysis of a long bone is essentially one of fracture, although none of the classical signs of fracture may be present because of the development of a supporting involucrum. From this fact it is obvious that pathological fracture is a complication of the chronic stage of osteomyelitis, except in certain cases of epiphyseal separa-

FIG. 1

Case 1. Massive sequestration of the lower third of the femoral shaft with fracture of the involucrum.

*From the Department of Surgery, University of Michigan

tion due to an extensive acute metaphysitis, as seen, for example, at the upper end of the femur.

As secondary factors there are then: (a) excessively large diaphyseal separation, and (b) the formation of an involucrum that is inadequate to stand the normal stresses brought to bear upon the limb. In addition, fracture is facilitated by imperfect immobilization and support of the diseased bone and is, therefore, more commonly found in the single bones —the humerus and the femur—than in those that have a companion bone for support.

The above indicates diagnostic and therapeutic errors of omission. The most important error of commission is seen in the excessive zeal of the surgeon in the removal of large segments of the circumference of the shaft of the bone or of the supporting involucrum, and in his application of undue force to a structure incapable of standing even normal stresses.

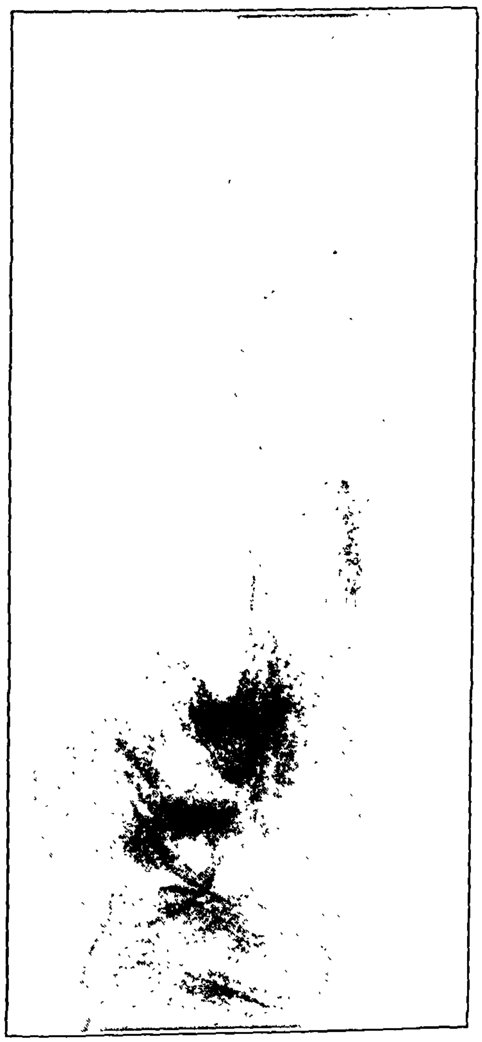

FIG. 2-A FIG. 2-B

Case 3. Metaphyseal fracture at the lower end of the femur. *A*. Before sequestrectomy. *B*. Solid union but poor position.

While error of judgment should undoubtedly be blamed, it is only fair to mention that one more important factor must be borne in mind. Long-standing atrophy of disuse, with the decalcification consequent upon prolonged hyperaemia, produces a soft spongy tissue that has a much greater fragility than normal bone.

It is beyond the scope of the present article to discuss any further the errors in diagnosis and early treatment already mentioned and which have been adequately dealt with by numerous other writers. We do believe, however, that a few remarks are desirable upon the surgical errors found in the operative treatment of late cases of osteomyelitis.

In the modern treatment of the disease attention has rightly been taken from the use of antiseptic solutions for the irrigation of cavities and stress laid on the complete opening up of these cavities to the surface and

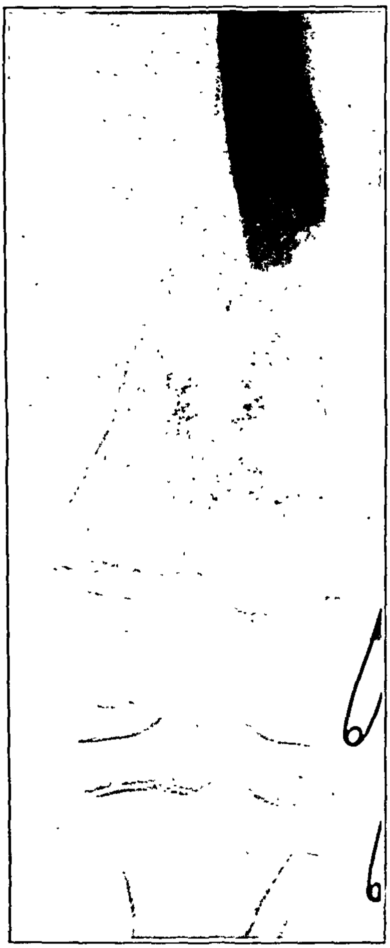

FIG. 3-A

FIG. 3-B

Case 10. Fracture through central abscess. *A.* On admission. *B.* On discharge with union.

to the removal of infected and necrotic material. To effect this, "guttering" and "saucerization" of lesions have been advocated, the cavities being allowed to become obliterated, partly as the result of the falling in to them of muscles and partly by the inward growth of granulation tissue with resultant scarring. This principle is undoubtedly correct, but where the attention of the surgeon has been directed to the production, by his operative treatment, of a shallow "saucer" rather than to a moderately deep "gutter", there danger has arisen. Overzealous removal of bone is then a great surgical error which is assisted in the formation of fractures by the use of unnecessary violence, especially that produced with the hammer and gouge and by inadequate splinting after operation.

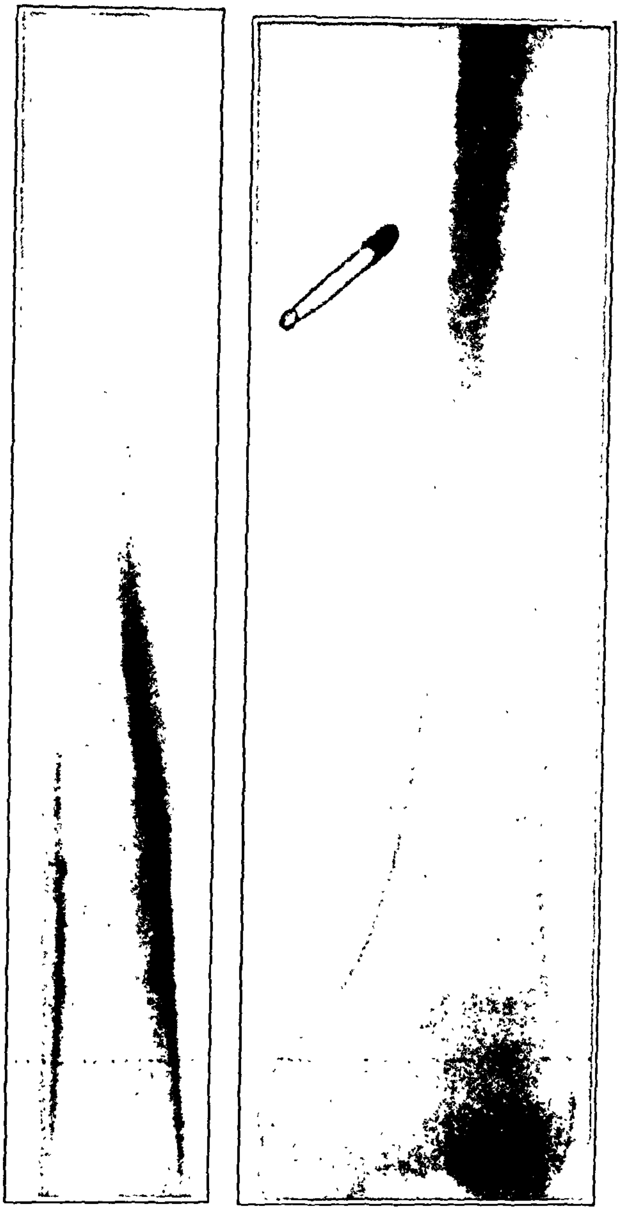

FIG. 4-A FIG. 4-B

Case 12. Chronic osteomyelitis with extensive central bone abscesses. *A*. Before treatment. *B*. After "saucerization"—fracture. An example of excessive operative removal of bone.

When removing a large sequestrum, its enveloping involucrum should be very carefully conserved. If a linear series of chisel cuts be made in the involucrum throughout the length of the sequestrum, the former may often be opened up sufficiently to allow the latter to be extracted.

The ability of bones, weakened by operation, to modify their shape and strength in response to the stimulus of function, in order adequately to bear the stresses brought to bear upon them, is remarkable. Assistance to this end should be given by graduated exercises with proper support. Bone production is of course dependent in part upon the calcium content of the surrounding tissues and Murray[1] has recently suggested the use in clean bone cavities of masses of calcium salt as an accessory to the development of new bone.

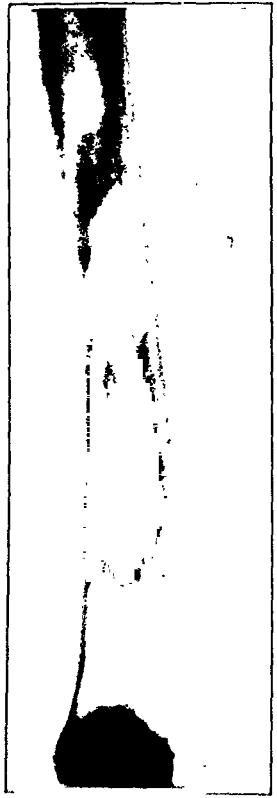

FIG. 5-A

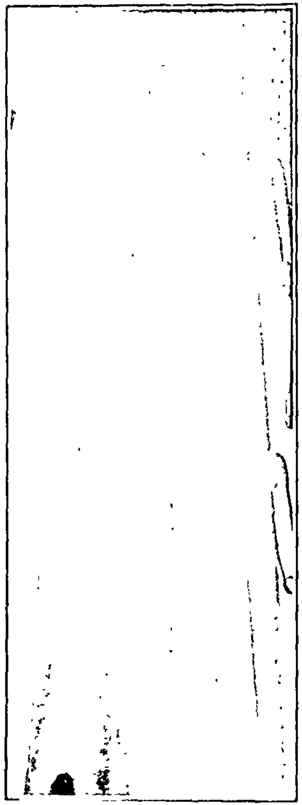

FIG. 5-B

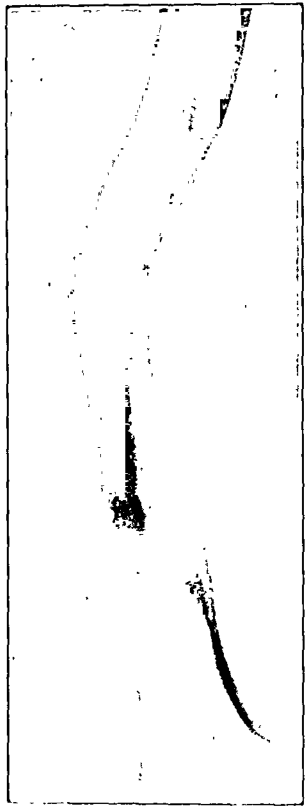

FIG. 5-C

Case 13. Multiple chronic bone abscesses. *A*. Before treatment. *B*. After "saucerization" fracture. *C*. Lateral view after solid union has occurred. An example of excessive operative removal of bone.

FIG. 6

Case 14. Fracture of femur through "saucerized" area.

In extensive lesions of the long bones, fractures should be anticipated by treating them as such—immobilizing the joints above and below the lesion except for carefully supervised exercises. The most efficient splint available should be employed, and most often this will be found to be a mold of plaster-of-Paris in the earlier stages and, for the lower extremity, a caliper brace during convalescence.

In the tabulation of data relating to the eighteen patients with pathological fracture in the present series, it will be seen that there were thirteen patients with fracture of the femur, one of whom had a fracture of both femora and two of whom had refractures at the same site after a previous union. With two exceptions all these fractures of the femur were at or below the junction of the lower and middle thirds. There were three patients with fracture of the middle of the shaft of the humerus,—one of these had a refracture; another of these patients also had a pathological fracture of the clavicle. The remaining two patients had fractures of the

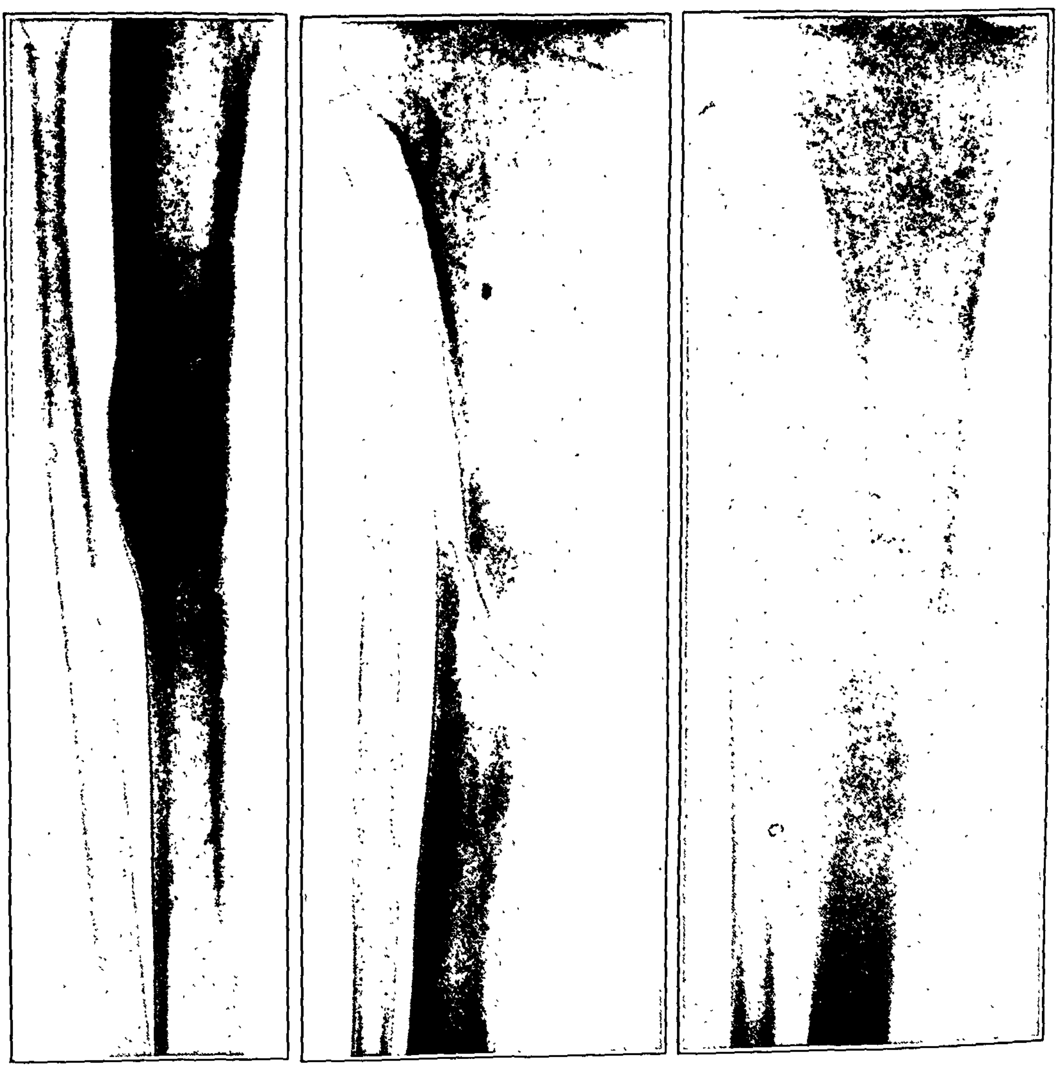

Fig. 7-A Fig. 7-B Fig. 7-C

Case 15. Single bone abscess of tibia. *A*. Before operation; bone sclerosis overshadows the abscess. *B*. After fracture. *C*. Partial union.

tibia and of the ulna respectively. Of the twenty-four fractures (including refractures) five occurred before operation, four at operation, and the remaining fifteen after operation.

TABLE I

Total number of patients with osteomyelitis, October 1925–March 1931	1086
Total number of pathological fractures of all kinds	54
Osteomyelitis of shaft of long bones	18
Osteomyelitis with separation of epiphysis secondary to septic arthritis	4
Neurotrophic lesions	12
Metastatic carcinoma	8
Alveolar abscess	2
Cyst	2
Old fracture	2
Sarcoma	1
Chondroma	1
Giant-cell tumor	1
Rickets	1
Tuberculosis	2
Percentage of pathological fractures in osteomyelitis	1.66 per cent.
Percentage of cases of osteomyelitis of shaft of long bones in total pathological fractures	33.33 per cent.

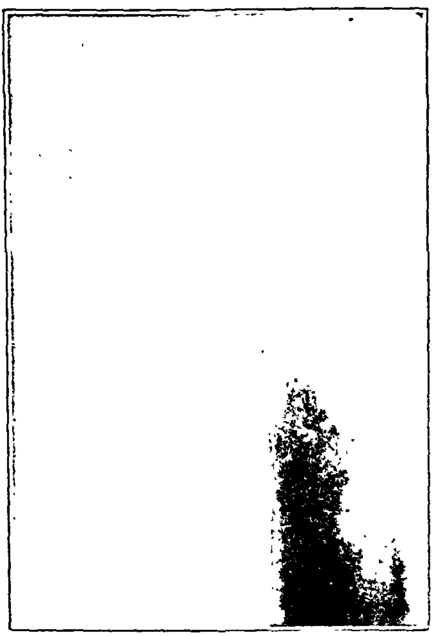

FIG. 8-A

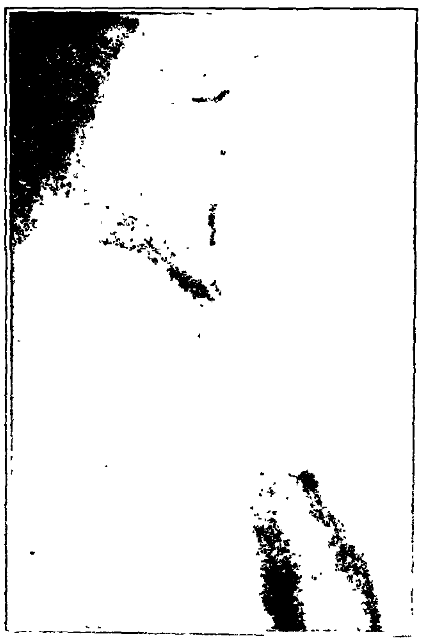

FIG. 8-B

Case 17. Subtrochanteric bone abscess. *A*. After operation with fracture. *B*. Union (solid clinically).

TABLE II

No. of Case	Sex	Age	Site of Fracture	Type of Lesion	Operation	Nature of Trauma	Time of Fracture	Result
1	M	15	Femur, left (lower third).	Chronic with massive sequestration.	No operation.	Slight trauma.	Before admission.	Patient lost sight of.
2	M	33	Humerus, right (mid-shaft).	Sclerosing with acute exacerbation.	Saucerization.	During transfer to operating table.	At operation.	Weak, bony. Refractured 6 months later, non-union resulting.
3	M	11	Femora, right, intertrochanteric: left, supracondylar.	Subacute with massive sequestration.	No operation before fractures.	Indefinite trauma.	Before first admission.	Weak, bony union. Recent case.
4	F	14	Femur, right. Junction middle and lower thirds. Fractured three times.	Chronic with sequestration.	No operation before first fracture; saucerization 1 year before second fracture and again 3 months before third.	First fracture at age of 4 years. Second fracture while playing on floor without support; third fracture, leg dropped during dressing.	Second fracture 1 year after operation. Third fracture 3 months after operation.	There was non-union and patient died from pyaemia and secondary infection of wound with actinomyces.
5	M	14	Femur, left (lower third).	Chronic with massive sequestration.	Operation: sequestrectomy and saucerization.	Operative manipulation.	At operation.	Firm bony union.
6	M	13	Clavicle, left; humerus, left.	Chronic with massive sequestration, both bones.	Sequestrectomy and saucerization both bones.	Not recognized at time of fracture.	At operation (clavicle). Post-operative (humerus).	Union with total regeneration of clavicle. Solid union of humerus with no disability from either fracture.
7	M	16	Ulna, left (lower metaphysis).	Central abscess. No sequestration.	Saucerization.	Operative trauma.	At operation.	Perfect union. No disability.
8	M	21	Humerus, right.	Chronic with massive sequestration.	Sequestrectomy and saucerization.	Operative trauma.	At operation.	Weak, bony union but patient died 6 months later of pyaemia.
9	F	13	Femur, left (middle and lower third).	Sclerosing type.	Saucerization.	During changing of cast.	2 months after operation.	Non-union. Walking in caliper. Wound healed.

(Continued on next page)

TABLE II—*Continued*

No. of Case	*Sex*	*Age*	*Site of Fracture*	*Type of Lesion*	*Operation*	*Nature of Trauma*	*Time of Fracture*	*Result*
10	F	10	Femur, left (middle and lower third).	Chronic with massive sequestration.	No operation on bone prior to fracture.	Fell while walking with crutches.	Preoperative.	Solid union but with shortening of 2 inches.
11	M	14	Femur, left (junction middle and lower thirds).	Chronic sclerosing, multiple central abscesses.	Saucerization on three occasions.	Tripped on carpet through patient's carelessness.	5 months after last operation.	Delayed but strong union. Walks with caliper.
12	F	16	Femur, right (junction lower and middle thirds). (2 *fractures*.)	Chronic with multiple central abscesses. No sequestrum.	Saucerization.	Operative trauma. Refractured later in bed through patient's negligence.	Second fracture 6 months after operation.	Non-union. Died following erysipelas and wound diphtheria.
13	M	32	Femur, right.	Chronic osteomyelitis with central abscesses.	Saucerization.	Struggled during dressing under general anaesthesia.	4 days after operation.	Solid union. Walks without support.
14	F	29	Femur, left (junction middle and lower thirds). (2 fractures.)	Chronic osteomyelitis with central abscesses.	Saucerization.	Jumped out of bed in fright.	First fracture 6 months after operation. Refractured at operation here.	Malunion with shortening. Still under treatment.
15	M	24	Tibia, left (middle third).	Chronic central diaphyseal abscess.	Saucerization.	Sudden twist upon leg. Violence sufficient to fracture normal tibia.	6 weeks after operation.	Delayed but solid union.
16	M	10	Femur, left (junction middle and lower thirds)	Acute osteomyelitis.	Incision and drainage of subperiosteal abscess, and medulla.	Blow on uncovered but supported thigh.	8 weeks after operation.	Solid union. Walks without support.
17	M	11	Femur, left (subtrochanteric)	Chronic central abscess	Small window drainage of abscess.	Slipped and fell while walking with crutches. No other support.	3 weeks after operation.	Delayed, solid union; walks with caliper. Recent case.
18	M	17	Femur, left (supracondylar).	Subacute osteomyelitis.	Saucerization.	No definite trauma; discovered during dressing; limb in long leg cast.	5 days after operation.	Amputation on account of non-union and virulent infection of knee joint.

SUMMARY

1. Pathological fracture in cases of osteomyelitis of the shafts of long bones has occurred in one and two-thirds per cent. of a total of 1086 cases. Osteomyelitis has been responsible in this clinic for thirty-three and one-third per cent. of all pathological fractures in long bones.
2. Correct diagnosis and proper treatment at the earliest stage of the disease is obviously the most important prophylactic measure.
3. Every case with massive sequestration must be regarded as a fracture before abnormal mobility or deformity is evident.
4. A deep gutter rather than a shallow saucer is a safer mechanical means of dealing with central bone abscesses. In the removal of sequestra the involucrum should be conserved.
5. Careful attention should be paid to the proper provision of splints or other support during convalescence.

The writers wish to acknowledge their indebtedness to Dr. Frederick A. Coller, Director of the Department of Surgery, University of Michigan, who has given valuable assistance in the conduct of this inquiry.

REFERENCE

1. Murray, Clay Ray: Delayed and Non-Union in Fractures in the Adult. Ann. Surg., XCIII, 961, May 1931.

SPONDYLOLISTHESIS AND VERTEBRAL ANOMALIES IN SKELETONS OF AMERICAN ABORIGINES. WITH CLINICAL NOTES ON SPONDYLOLISTHESIS *

BY RUSSELL T. CONGDON, M.D., F.A.C.S., WENATCHEE, WASHINGTON

I. VERTEBRAL ANOMALIES IN SKELETONS OF AMERICAN ABORIGINES

In the pursuit of archeological explorations, the writer has had the good fortune to discover several skeletons in which there was a spondylolisthesis. In each case the spondylolisthesis was accompanied by a bilateral separation of the neural arch. The etiological relationship of the defect in the vertebral arch to the spondylolisthesis present was strikingly suggested.

FIG. 1

Anatomical Specimen 27. Spondylolisthesis of fifth lumbar vertebra with bilateral separation of the neural arch. The posterior separated portion of the neural arch (A) is mounted in a posterior position to better show its outline.

FIG. 2

Anatomical Specimen 38. Spondylolisthesis of fourth and fifth lumbar vertebrae. Bilateral separation of arches of both fourth and fifth lumbar vertebrae. There is marked bone excrescence about both articulations, more pronounced at the lumbosacral articulation.

* Submitted for publication August 1, 1931.

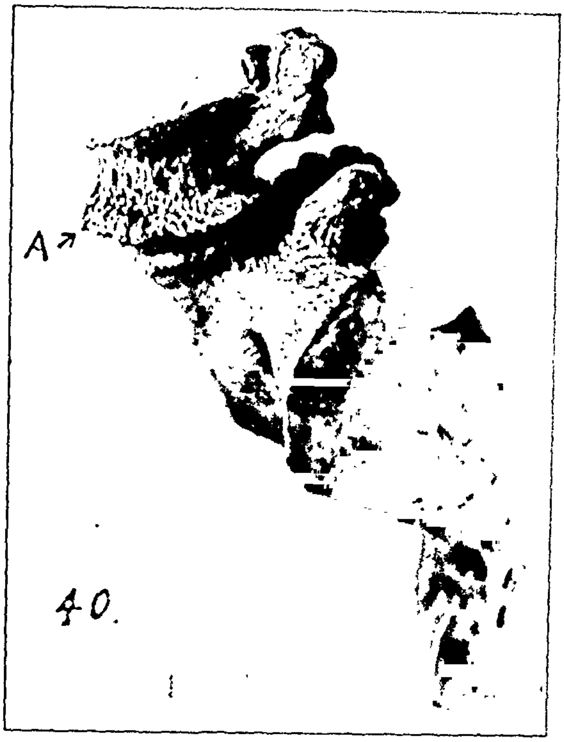

FIG. 3

Anatomical Specimen 40. Spondylolisthesis of fifth lumbar vertebra, accompanying bilateral separation of the neural arches of the fifth lumbar and first sacral vertebrae. A flaring ridge of excrescent bone encircles the lower third of the body of the fifth lumbar vertebra (*A*). The posterior separated portions of the arch are not shown.

FIG. 4

Anatomical Specimen 42. Bilateral separation of neural arch of fifth lumbar vertebra with spondylolisthesis. A heavy, shelving ridge of bone projects out beneath the fifth lumbar from the anterior surface of the first sacral segment (*A*).

B. The separated, posterior portion of the neural arch.

In view of the interest shown at the present time in vertebral defects and variations in the lumbosacral articulation, and their clinical bearing, a description of these specimens is presented. A roentgenographic study of the specimens was made and the findings correlated with the roentgenographic findings in the writer's clinical cases of spondylolisthesis. Certain deductions from this study are offered for consideration.

The anatomical material on which this study is based comprises nearly two hundred skeletal remains of American aborigines, obtained in the course of archeological investigations in the Columbia River region.

Bilateral separation of the neural arch was found in ten subjects. This occurred in the fifth lumbar vertebra in nine subjects, in the fourth lumbar in one; in one of the nine subjects, the bilateral defect occurred in both the fourth and the fifth lumbar vertebrae.

Striking changes in the bone structure of the vertebral body are present in these defective vertebrae. There are, also, marked changes in the structure of the first sacral body, related to the structural changes in the accompanying defective fifth lumbar. These changes are limited to the articulation between the defective fifth lumbar vertebra and the sacrum. They do not involve the remaining intervertebral articulations,

except in the two cases in which the separation of the arch occurs in the fourth lumbar. These changes in bone contour are so marked in many of the specimens that it is possible to reconstruct,—that is, to place the defective vertebra on the upper surface of the sacrum in the position which it occupied during the latter part of the life of the individual. In five of the subjects in which this has been done, there is apparent a definite spondylolisthesis (Figs. 1, 2, 3, and 4).

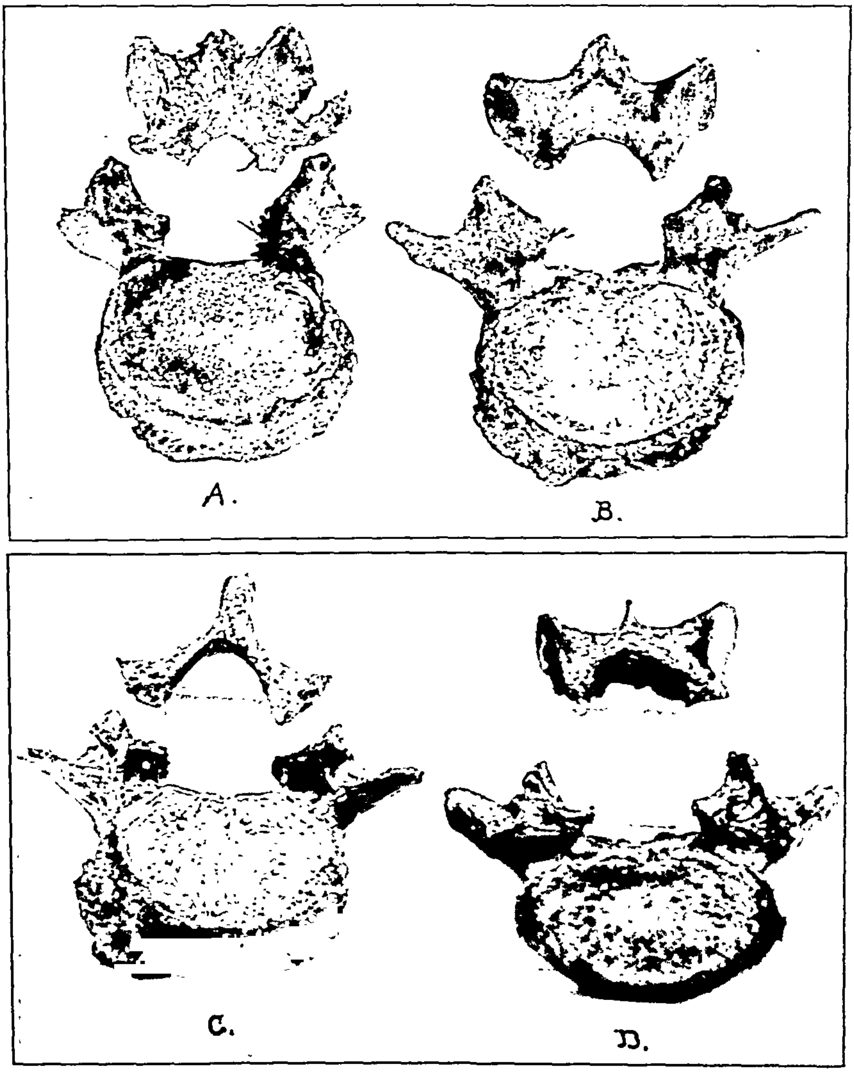

Fig. 5

Bilateral separation of the neural arch.
A. Fourth lumbar vertebra.
B. Fifth lumbar vertebra of Anatomical Specimen 38 (Fig. 2).
C. Fifth lumbar vertebra of Anatomical Specimen 42 (Fig. 4). Pronounced collar of excrescent bone accompanying the spondylolisthesis.
D. Specimen 60, fifth lumbar.

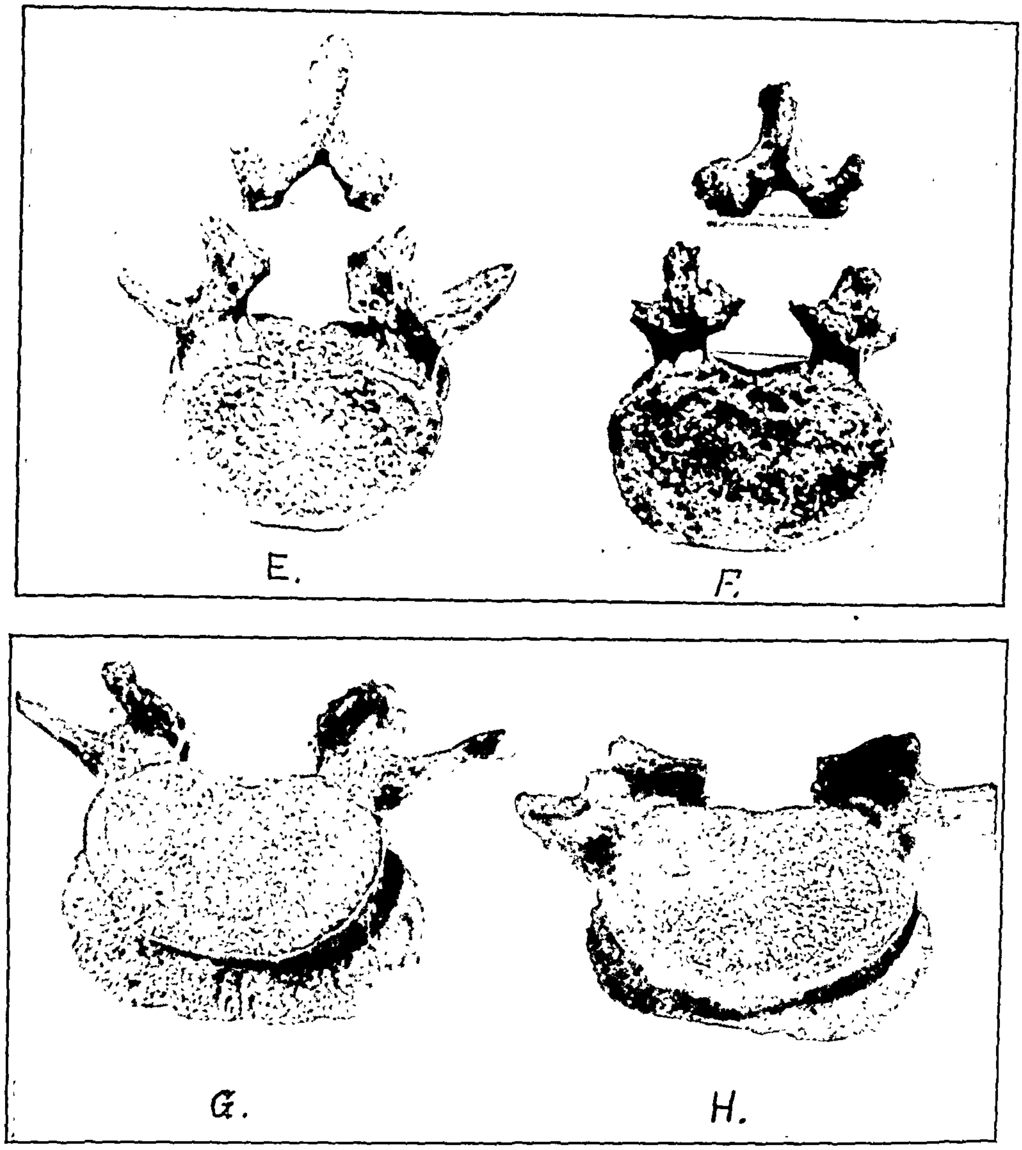

FIG. 6

Bilateral separation of neural arch.
E. Anatomical Specimen 41, fifth lumbar.
F. Anatomical Specimen 47, fourth lumbar.
G. Fifth lumbar vertebra of Anatomical Specimen 40 (Fig. 3).
H. Anatomical Specimen 44, fifth lumbar vertebra. The flaring lip of excrescent bone is well marked in the latter two spondylolisthetic vertebrae.

Examination of the vertebrae, in which bilateral separation of the arch is present, shows that the separation has occurred at a point where the laminae join the pedicles,—that is, between the superior and inferior articular facets (Figs. 5, 6, and 8). The vertebra, then, is divided into two entirely separate parts,—the body, with the pedicles, transverse processes, and superior articular processes, constituting the anterior portion; while the laminae, spinous process, and inferior articular processes comprise the posterior portion. The posterior portion, then, bearing the inferior articular facets, is devoid of any bony attachment to the body of the vertebra.

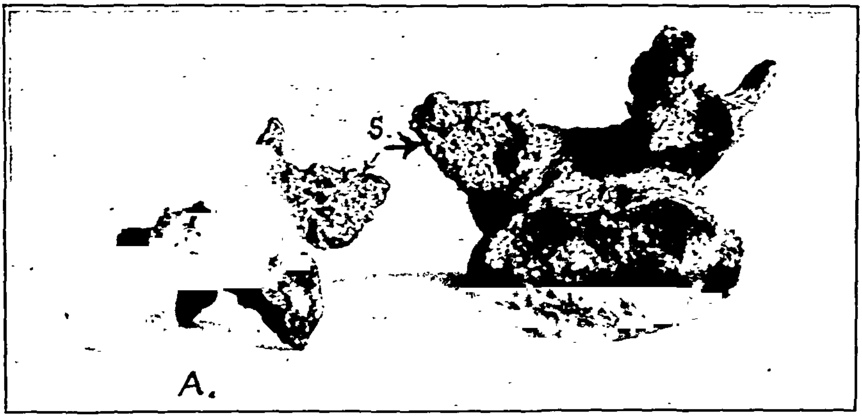

FIG. 7

Fifth lumbar vertebra of Specimen 27. Bilateral separation of the neural arch. Here, the plane of separation on the left side varies from the usual interarticular position. It extends through the pedicle. *A* is the posterior part of the arch. The rough, pitted surfaces, resembling an epiphyseal surface, are shown at *S*.

In one of the vertebrae there is a variation in the position of the defect. In this specimen (Fig. 7) the plane of non-fusion on the left side extends obliquely through the pedicle and transverse process, leaving the left superior articular, as well as inferior articular, process as part of the posterior portion of the defective vertebra.

The articular processes of these defective vertebrae are well formed and the facets are normal. The inferior facets conform in size and shape to the corresponding superior facets of the segment below, with which they articulate. The spinous processes are well formed; none are bifid.

The instability of the spine, resulting from this laminar defect, is clearly portrayed by these specimens. Deprived of the holding power of the inferior articular processes, the position of the vertebral body was

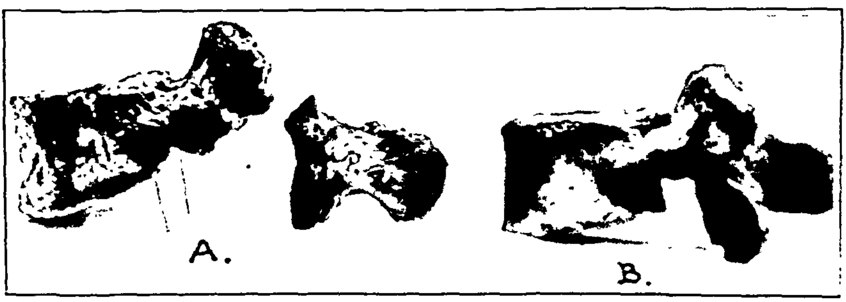

FIG. 8

A. Specimen 41. Bilateral separation of neural arch, fifth lumbar vertebra. The laminar defect is seen to be situated between the superior and inferior articular processes. The inferior articular processes, therefore, are a part of the posterior, separated portion of the arch. With this "anchor" separated, the vertebral body is deprived of its main holding structures; the stability of the articulation is greatly diminished.

B. Normal fifth lumbar for comparison.

maintained by ligaments. These were subjected to a stress far greater than they are normally called upon to meet.

That the ligaments alone were unable to maintain the fifth lumbar body in normal position under these conditions is clearly shown in a large percentage of the specimens in the writer's collection, in which there is bilateral separation of the arch. Placing the body of the defective fifth lumbar vertebra on the superior surface of the sacrum of the same subject, it is apparent from the molded shapes of the opposing surfaces that the body has moved forward and downward on the sacrum (Figs. 1 and 4). The extent of forward displacement varies in five of the specimens from one-third to one-half of an inch. Accompanying this spondylolisthesis there are marked bony changes. The anterior margin of the first sacral segment is rounded off or beveled (Fig. 9). Most striking, however, is the flaring, collar-like ridge of excrescent bone (Fig. 4, *A*), formed on the anterior surface and lateral margins of the first sacral segment, beneath the overhanging portion of the fifth lumbar body. A similar collar of excrescent bone encircles the body of the defective fifth lumbar vertebra a little distance above its lower margin (Figs. 2 and 3). This hypertrophic arthritis is limited to the articulation of the fifth lumbar with the sacrum. In Specimen 38 (Fig. 2) both the fourth and fifth lumbar vertebrae show bilateral separation of the neural arch. There is marked hypertrophic arthritis at both the articulation of the fourth and fifth lumbar vertebrae and the lumbosacral articulation, but none at the other vertebral articulations.

This hypertrophic arthritis, localized at the inferior articulations of those vertebrae which have defective separated neural arches, is uniformly present. It is a reaction to strain, and may reasonably be interpreted as evidence of the instability of the articulation.

The defect in the arch, as previously stated, occurs through the laminae between the superior and inferior facets. This is its situation in ten of the eleven specimens in the author's collection. The variation from this common form is shown in Figure 7. Close examination of these vertebrae reveals two facts which have a bearing on the nature of the defect: First, the surface of the bone at the point of non-fusion of the arch is roughly pitted and irregular (Fig. 7, *S*). This closely resembles the appearance of an epiphyseal surface. Second, although there are slight variations in the position and pattern of the bone surfaces of the defects, on comparison of one vertebra with another, there is a striking similarity between the defects on either side of the same vertebra. This similarity of the defects in the two sides of the arch of the same vertebra is interpreted by the writer as evidence of a developmental origin. Were the separations of the arch due to fracture, it is far more likely that the lines of fracture through the laminae would differ considerably on the two sides, because of variation in the direction of application of the force producing the fracture. In Specimen 40 (Fig. 3) there is bilateral separation of the neural arch of the first sacral as well as of the fifth lumbar vertebra. The

possibility of fracture of the laminae can be eliminated with certainty in the first sacral arch, since the body and pedicles of this segment are an integral part of the sacrum and sheering strain could not take place. The defects in these two segments present the same appearance. To hold that the separation in the one case were due to a developmental defect and in the other to fracture would hardly be logical. These observations are in accord with the generally accepted theory that the cleft in the arches is due to a congenital anomaly in the bone nucleus formation, with imperfect ossification of the laminae.[1]

This defect, bilateral separation of the neural arch, probably occurs more frequently than is generally recognized. In the writer's material it was present in ten subjects out of 200, or five per cent. This approaches closely the figures of Willis,[2] who found it present in four and eight-tenths per cent. of 850 skeletons examined by him.

ROENTGENOGRAPHIC STUDY

A roentgenographic examination was made of several of the archeological specimens in the writer's collection, with the following results.

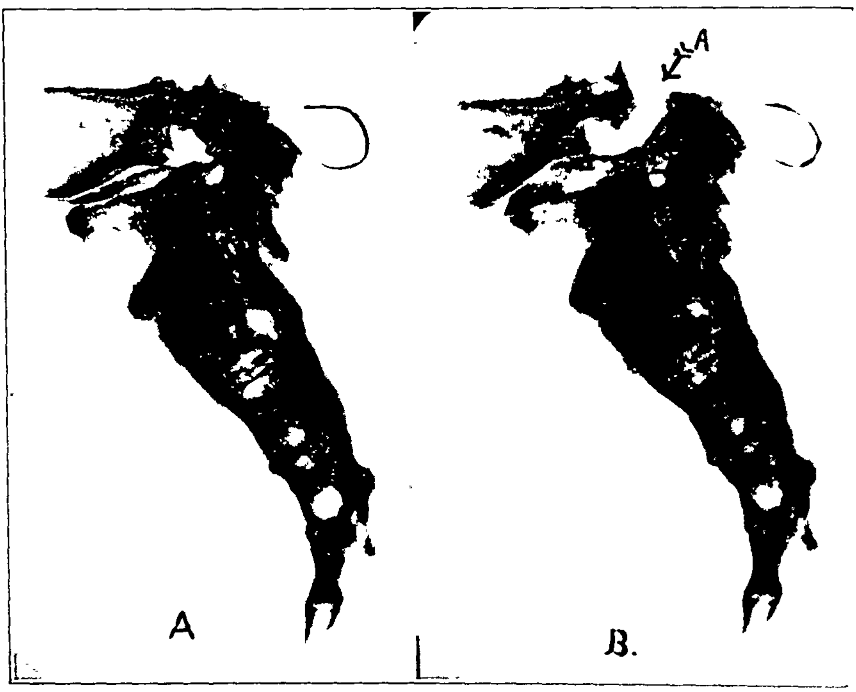

Fig. 9

Lateral roentgenograms of Specimen 27, shown in Fig. 1. Spondylolisthesis with bilateral separation of the neural arch.

A. With the anterior and posterior parts of the divided neural arch approximated, the defect is scarcely discernible.

B. With the vertebral body placed in its position of spondylolisthesis, the defect is clearly seen. Laminar defect indicated by arrow, *A*.

When the defective fifth lumbar vertebra is placed in approximately its normal position on the upper surface of the sacrum, and the posterior portion of the non-fused arch is approximated to the anterior portion, the defect is not definitely shown by the roentgenograms. In the lateral view there may be shown an indistinct line or thinning out at the site of the separation (Fig. 9). In the living subject, this would be entirely obscured by the overlying ilia and soft tissues. When, however, the body of the defective vertebra is moved anteriorly one-third to one-half of an inch, corresponding to its position in spondylolisthesis, the posterior portion of the arch remaining in normal position with its facets articulated with the sacral facets, lateral roentgenograms of the anatomical specimens show clearly the defect or separation (Figs. 9 and 10). In the living subject, because of the deep-lying position of the fifth lumbar, it is improbable that this defect could be demonstrated except in the presence of a considerable separation of the two portions of the arch, such as would exist in a more pronounced condition of spondylolisthesis.

Examination of the roentgenograms of the anatomical specimens shows

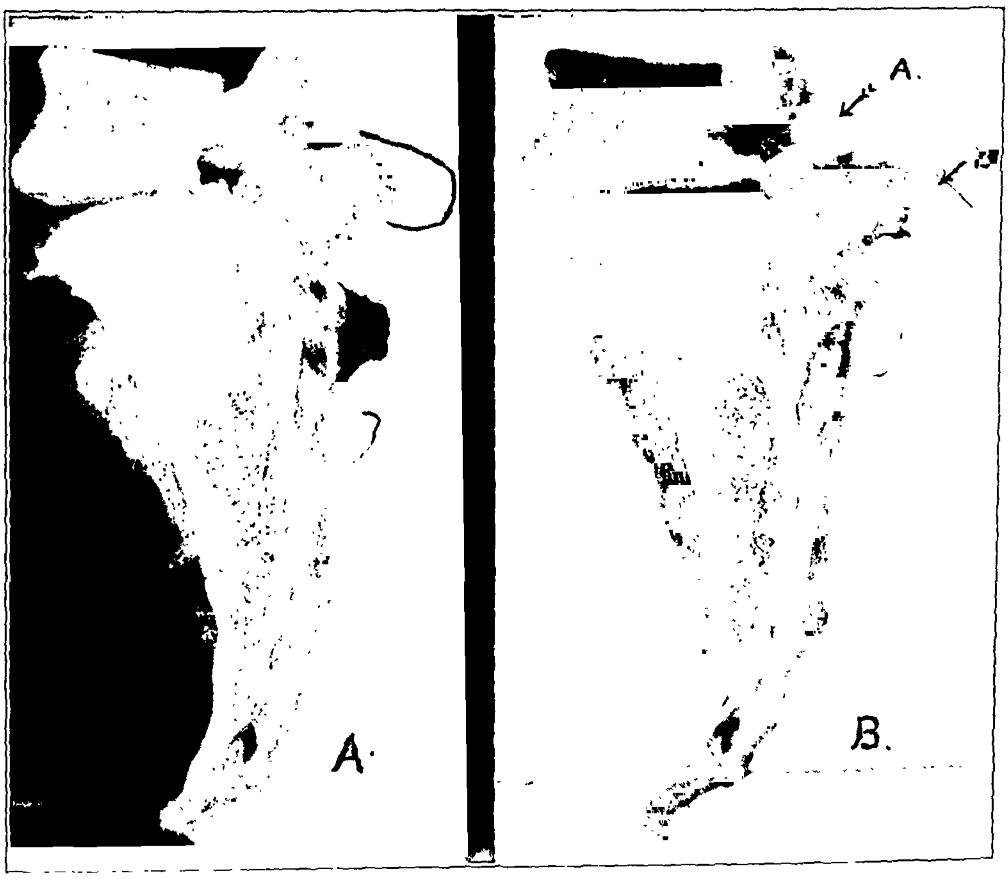

Fig. 10

Lateral roentgenograms of Specimen 42 shown in Fig. 4.
A. Defect not definitely shown when the two parts of the divided vertebral arch are approximated.
B. With the lumbar body in its position of spondylolisthesis, the laminar defect is clearly demonstrated. Defect at *A*. *B* shows spinous process and posterior portion of separated neural arch. (See Fig. 4.)

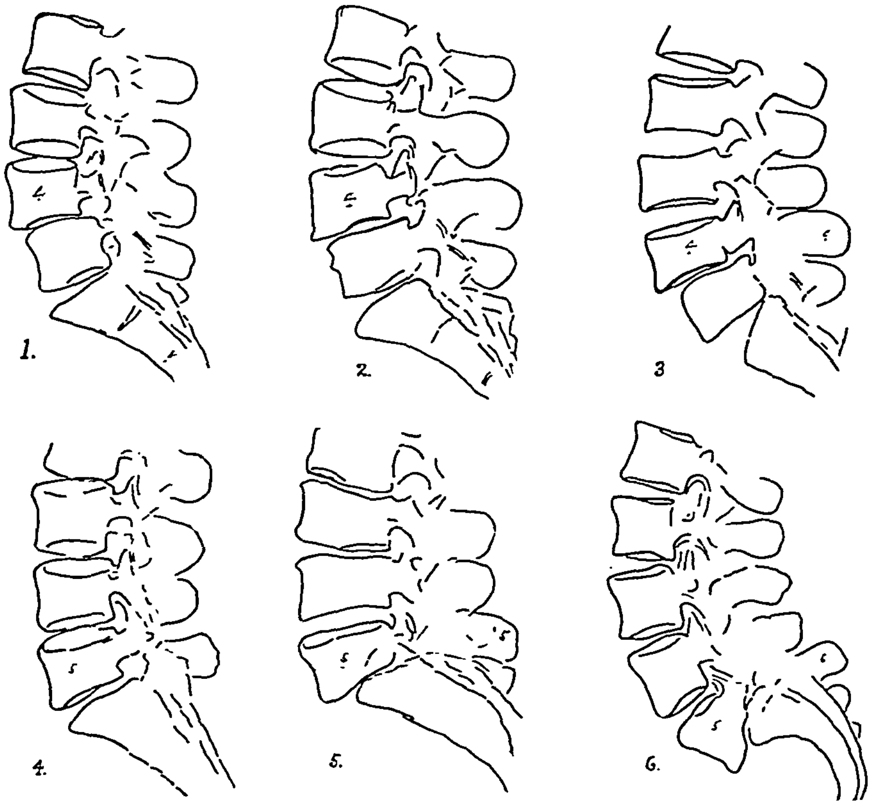

FIG. 11

Roentgen-ray tracings of patients. *1*, Case 1; *2*, Case 1 two years later. *3*, Case 2, anterior displacement of fourth lumbar vertebra. Tracings *4*, *5*, and *6* are of cases 3, 4, and 5, respectively. Spondylolisthesis of fifth lumbar.

In each case the spinous process has remained in its normal or posterior position, while the body of the vertebra and the anterior portion of the neural arch have been displaced anteriorly. The anteroposterior diameter of the vertebra involved, in each case, is seen to be increased in accordance with the amount of forward displacement of the body of the vertebra.

that the anteroposterior diameter, or measurement from the anterior border of the body to the posterior margin or tip of the spinous process of the vertebra, is increased according to the amount of forward displacement of the body (Figs. 9 and 10).

II. CLINICAL OBSERVATIONS

With these facts in regard to the roentgenographic appearance of the anatomical specimens in mind, the writer reviewed his clinical cases of spondylolisthesis (not Indian). A careful study of the roentgenograms was made in an effort to determine whether or not an associated vertebral defect could be demonstrated.

In only one of the five patients could a defect in the neural arch be definitely visualized, Case 3 (Fig. 11). Although the bilateral defect may

not be visualized in the roentgenogram, its presence may nevertheless be determined indirectly.

In our study of the anatomical specimens (Indian) of spondylolisthesis with bilateral laminar defects, it was observed that the anteroposterior diameter of the vertebra involved was increased.

The same observation was made on examination of the lateral roentgenograms of the clinical cases. In each case the anteroposterior diameter of the vertebra involved in the spondylolisthesis is greater than that of the other lumbar vertebrae. The amount of increase corresponds to the extent of forward displacement of the body. This detail is lost in the reproductions of the roentgenograms, but is clearly shown in the tracings (Fig. 11).

This increase in the anteroposterior measurement of the vertebra necessarily means that the vertebral body has moved forward, while the posterior portion of the neural arch has remained in the position which it occupied before the spondylolisthesis developed. It is, therefore, evidence of a separation or break in continuity of the neural arch.

Bowman and Goin [3] state that rarely, if ever, can this condition be recognized by means of roentgenographic examination. Sutherland [4] reported on a study of developmental anomalies of the spine. Roentgenographic examination of the lumbar spine and sacrum was made in approximately 12,000 of a consecutive series of 60,000 patients at The Mayo Clinic. He makes no mention of the observation of bilateral separation of the arch, while spina bifida occulta, involving the fifth lumbar, was found in one and three-tenths per cent. of the cases. In contrast to this, Willis, in his anatomical study, found spina bifida occulta in one and two-tenths per cent. of the specimens examined, while the bilateral defect in the arch was present in four and eight-tenths per cent. This study would indicate, then, not the rare occurrence of this defect, but that the existence of the defect cannot generally be demonstrated by roentgenography.

In view of this difficulty in detecting the presence of a bilateral separation of the arch, we believe that this observation, that there is an increase in the anteroposterior diameter of the vertebra involved in spondylolisthesis, is an important aid in determining the presence of a bilateral defect in the arch.

Study of the anatomical specimens of spondylolisthesis, and examination of the roentgenograms of the writer's cases of spondylolisthesis, then, would indicate strongly that in the development of spondylolisthesis the posterior portion of the neural arch remains in its normal position, retained by the inferior articular processes and by the powerful interspinous ligaments, while the vertebral body, with the pedicles and superior articular and transverse processes, slides forward and downward.

Any operative procedure, undertaken to stabilize the lumbar and lumbosacral region for the relief of symptoms resulting from spondylolisthesis, should be based on an understanding of the underlying pathol-

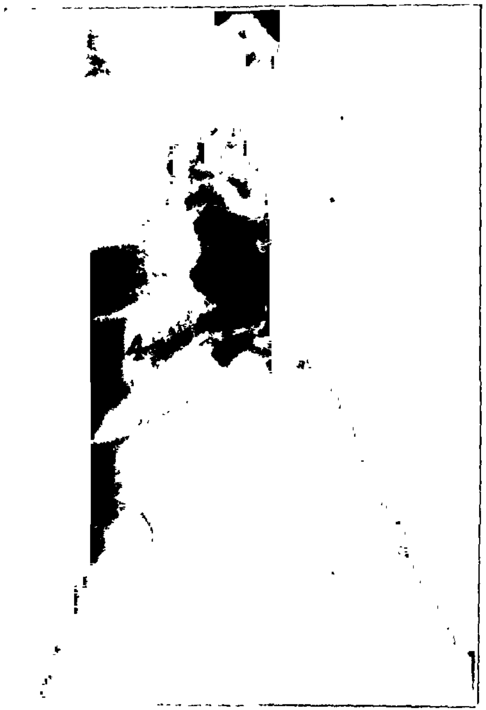

FIG. 12

Case 1. Lateral view. Spondylolisthesis of fourth lumbar vertebra. Ridge of excrescent bone indicated by arrow, same as Tracing 2, Fig. 11.

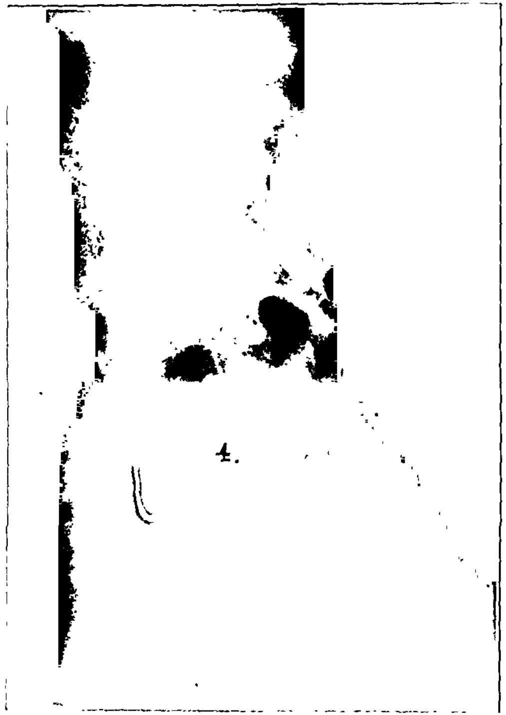

FIG. 13

Case 2. Lateral view. Spondylolisthesis of fourth lumbar vertebra. Same as Tracing 3, Fig. 11.

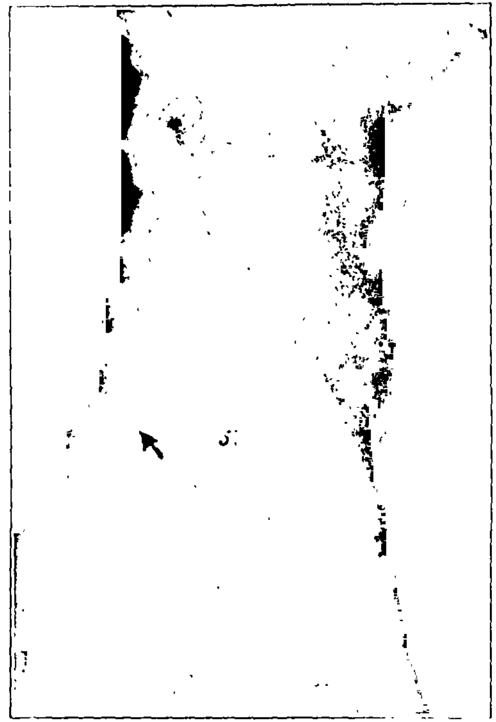

FIG. 14

Case 3. Lateral view. Spondylolisthesis of fifth lumbar vertebra. Laminar defect indicated by arrow. Corresponds to Tracing 4.

ogy. In the presence of a bilateral separation of the neural arch, the insertion of a single bone graft into the split spinous processes, extending above and below the lumbosacral articulation, will not accomplish the purpose intended. It should be borne in mind that the separation of the neural arch occurs in the fourth lumbar in a definite percentage of the cases. The fixation should then include the second and third lumbar vertebrae above and extend well down on the dorsum of the sacrum. A modified Hibbs fusion with the addition of tibial grafts, one placed on either side of the spinous processes, as carried out by Myerding,[5] offers a most satisfactory method of stabilizing the defective lumbosacral and lower lumbar articulations.

CASE REPORTS

CASE 1. Male, aged forty-four. "Hip trouble" had been present for more than a year, with pain in right thigh aggravated by walking, relieved by lying down. Symptoms began six weeks after a fall, when he alighted in a sitting position, got up and walked, experiencing no symptoms of injury.

Lateral roentgenograms showed spondylolisthesis of the fourth lumbar (Fig. 11, Tracing *1*). *Fusion operation was advised, but refused.*

When reexamined two years later, there was marked improvement in symptoms. Lateral roentgenogram shows about the same degree of spondylolisthesis. A ridge of excrescent bone had formed on the anterior border of the fifth lumbar (Fig. 11, Tracing *2*, and Fig. 12).

CASE 2. Male, aged forty-six. Received a severe back injury a year ago, when thrown against the wheel of a steam shovel. Examination showed a rigid lumbar spine. There was a prominence of the fourth lumbar spinous process with depression above, and angulation in the mid-dorsal region with deviation to the left.

X-ray examination: The anteroposterior view shows a compression fracture of the sixth dorsal vertebra. The lateral roentgenogram shows spondylolisthesis of the fourth lumbar (Fig. 13). The anteroposterior diameter of the vertebra is increased, indicating separation or fracture of the arch (Fig. 11, Tracing *3*).

CASE 3. Male, aged thirty-two. Had had pain in left hip and sciatic region for five years. One year before onset, he sat down hard, dropping a distance of three feet. Examination showed a tilting of the pelvis. The spinous process of the fifth lumbar was prominent, with a depression above.

X-ray examination: Lateral roentgenogram shows spondylolisthesis of the fifth lumbar vertebra. A laminar defect is visualized (Fig. 11, Tracing *4*, and roentgenogram, Fig. 14).

It is improbable that the injury in this case could have produced a fracture of the lamina. In the presence of a bilateral laminar defect, however, it is quite possible that a separation of the cartilaginous junction of the arch may have resulted.

CASE 4. Male, aged fifty-five, rancher. Gave a history of pain and burning sensation in lower back and legs for ten years; relief on lying down; severe pain on jarring. Examination showed the lumbar spine held rigidly, the normal curvature obliterated. There was a prominence of the fifth lumbar spinous process. X-ray examination shows extensive spondylolisthesis of the fifth lumbar vertebra. The spinous process has remained in its normal position on the dorsum of the sacrum. The anteroposterior measurement of the fifth lumbar is correspondingly increased (Fig. 11, Tracing *5*, and Fig. 15).

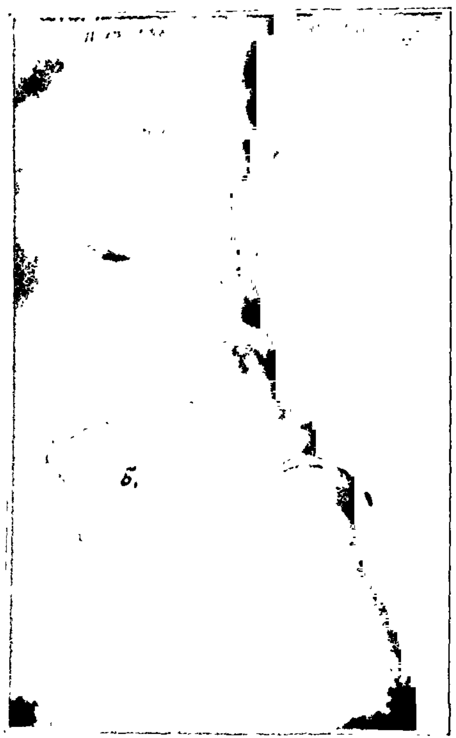

Fig. 15

Case 4. Lateral view. Spondylolisthesis of fifth lumbar vertebra. Corresponds to Tracing 5.

Fig. 16

Case 5. Lateral view. Advanced spondylolisthesis of fifth lumbar vertebra. Same as Tracing 6.

Fig. 17

Case 5. Anteroposterior view. Body of fifth lumbar vertebra hanging well below the top of sacrum.

CASE 5. Male, forty-two years of age. There was no history of injury. Patient complained of pain in the sacro-iliac region, and urinary frequency for two years. On examination there was apparent a marked depression over the region of the lower lumbar spinous processes with a prominence below. Roentgenographic examination confirmed the diagnosis of spondylolisthesis (Fig. 11, Tracing 6, and Figs. 16 and 17).

Of the writer's cases, two patients gave a history of definite severe trauma, and one had suffered a slight injury, while in the remaining two the onset was gradual with no history of definite injury.

The history of trauma should be carefully scrutinized. When spondylolisthesis develops gradually or following an injury of moderate severity—such as lifting a heavy weight—one is justified in considering that there was probably an underlying vertebral defect with resultant instability of the articulation.

SUMMARY

Bilateral separation of the neural arch was found in five per cent. of 200 skeletons examined.

Spondylolisthesis was present as an associated lesion in nearly fifty per cent. of the subjects having bilateral separation of the neural arch. The existence of this defect in the arch cannot generally be demonstrated, roentgenologically, in the living subject. When, however, spondylolisthesis is present and there is a considerable space between the two parts of the divided arch, the defect may be visualized. Its existence is suggested when the anteroposterior diameter of the vertebra involved in spondylolisthesis is greater than that of the other lumbar vertebrae, as seen in the lateral roentgenogram.

Bilateral separation of the arch results in a marked instability of the lumbar spine.

Increasing knowledge, gained from roentgenographic examination and operative findings, indicates that this defect is the fundamental etiological factor in a rather large group of cases of spondylolisthesis.

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OPERATIVE FUSION OF THE UNSTABLE OR FLAIL KNEE DUE TO ANTERIOR POLIOMYELITIS

A Study of the Late Results*

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HISTORICAL SURVEY

The first recorded case of fusion or arthrodesis of an unstable knee in a patient suffering from residual anterior poliomyelitis is attributed to Prof. Albert. Vulpius[28] stated that "this ingenious operation is associated with the name of Albert who first performed it on July 10, 1878, on a girl of fifteen with paralytic flail knee. Various other experiments to the same end had been made, as, for instance, the ignipuncture and injections. L. Bauer of New York had undertaken the resection of an unstable genu valgum after traumatic separation of the epiphysis, and Szymanowski and Braatz, the stiffening of a joint. It was Albert, however, who placed the operation on a systematic basis and applied it to the knee, ankle, elbow, and shoulder."

In 1885 von Winiwarter[29] demonstrated the specimen of a knee joint of a boy on whom arthrodesis had been performed. Zinsmeister[30], in 1887, reported four cases of Prof. Albert's and one of his own. S. Smith[22], in 1889, reported that he had arthrodesed the knee of a boy of ten and considered the result successful. Dollinger[5], in 1891, added two cases of his own and considered them fairly successful. Hofmokl[13], Kummer[16], and Beck[1] each reported a case between 1892 and 1896. Beck stated he had done similar operations subsequently. In 1900 Propper[21] reviewed the earlier cases of Albert *et al.* and added a case of his own.

The next ten years were rather silent on this operative procedure, although a great deal was written about the stabilization of other joints of the lower extremity. The tendon transplants were becoming increasingly popular. Bradford[4] reported one successful case in 1901. Gwynne[9] cited the case of a boy on whom he had arthrodesed both knee and ankle joints successfully. Jones[14] wrote that he had a number of poor people who trudged about without serious inconvenience with knee and ankle stiff. He felt that the procedure might be preferred by those who could not afford braces or were situated at long distances from a brace-maker. He condemned the procedure in children. Vulpius[28], in 1908, recommended knee fusion and stated that firm ankylosis should be obtained in seventy-five per cent. of the cases. Writing later, he stated that the procedure had declined in popularity but he still felt that it had much to recommend it.

In 1910 Hibbs[12] reported a new operative procedure for stiffening the

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unstable knee joint. His paper gave the details of the technique of mortising the patella into the denuded ends of the femur and tibia and suturing the periosteum of the patella over the front of the erased joint. In this report were included ten cases, the earliest done in January 1909.

Nathan[19], in 1914, wrote commenting unfavorably upon the procedure, but mentioned no cases that he had done. Frauenthal and Manning[6] in 1914 also wrote that "surgical stiffening of a joint has proved to be of most value for certain conditions of the ankle joint and must often be utilized for the flail knee". Soutter[24], in 1917, described a technique for arthrodesis of the knee joint. Lovett[17] in 1916 and 1917 stated that arthrodesis at the knee was not an operation to be lightly undertaken, because, to secure ankylosis in children, so much cartilage had to be removed that it might interfere with growth of the leg, and in adults it furnished a stiff knee which was awkward and unhandy. He felt that most people preferred a brace, and therefore considered that the operation should be discouraged. At a later date he wrote extensively on the operative treatment of the paralyzed leg, ignoring the flail knee.

Since 1920 Hallopeau[10], Hass[11], Kajon[15], Boorstein[2], Bossi[3], and Sorrel[23] have each reported one or two successful cases of arthrodesis of the flail knee. Orr[20], Stoffel[25], and Todd[27] have commented on the procedure, the latter considering it of doubtful value. In 1924 Thomson[26] reported four patients on whom he had done arthrodesis of a flail knee. He considered the results encouraging. Miller[18] in 1927 reported a series of twenty-five cases upon whom he had performed the Hibbs operation. These patients, ranging from nine to sixteen years of age, were greatly benefited in his opinion. Gray[7], in 1928, described the results in seven cases in which he had arthrodesed the knee joint. All of these patients were ten years of age or under. He stated that both parents and children were pleased with the result and he felt that the procedure should have a definite place in the surgery of infantile paralysis, provided bony union could be achieved with certainty. Guildal[8], in 1928, reported nineteen successful cases of arthrcdesis of the flail knee joint.

From the earliest recorded case of arthrodesis of the flail knee in 1878 until 1920 there were reported a scant thirty odd cases. Those surgeons advocating the procedure were on the defensive, while many of their colleagues denounced it in no uncertain terms. Since 1920 sixty-three cases, exclusive of this study, have been reported in the literature. The operation seems to have gained slowly but surely a definitely deserved place in the operative treatment of the residual paralyses of anterior poliomyelitis. Much of the dissatisfaction with this operation has probably been due to inability to obtain bony fusion. The earlier procedures were doubtless resections of the knee joint, which may have destroyed the epiphyseal lines in children and seriously interfered with growth of the leg. The operative technique employed in this series of cases obviates both these objections as will be shown.

REVIEW OF CASES

From the first case done at the New York Orthopaedic Hospital in 1909 until the end of 1927, a period of nineteen years, 154 operative fusions of the knee joint have been performed in cases of anterior poliomyelitis with an unstable or flail knee. It has been possible to follow and examine carefully during the past two years ninety of these patients in an effort to evaluate this operative procedure. Of the ten original cases reported by Hibbs in 1910, five have been followed and are embodied in this report.

Preoperative Physical Examination showed:

I. Eighteen patients with one lower extremity involved.
II. Five patients with one or two upper and one lower extremity involved.
III. Forty-six patients with both lower extremities involved.
IV. Eleven patients with both lower extremities involved, one of these very slightly.
V. Ten patients with one or two upper extremities and both lower extremities involved.

The extent of paralysis has an important influence on the end result as is shown subsequently.

Lateral Curvature

In thirty-eight patients the spine showed a lateral curvature of varying degree.

Difference in Length of Legs

The average difference in length between the sound or less affected leg and the paralyzed leg was one and one-half inches.

Prior Treatment

All of these patients had worn braces, either stiff-knee or with a catch at the knee to allow flexion while sitting. Many of them had worn braces for both legs. They had all had massage and some of them various forms of electricity. Two or three of these patients had had a biceps tendon transplant into the patella which had failed to stabilize the knee joint.

Reason for Submitting to the Operation

Invariably the reason was to get rid of the brace and at times to get rid of one brace. Anyone who has seen these patients return time after time for brace repair, new braces, etc., and realizes that without the brace they are helpless, will readily understand their eagerness to discard the brace. These patients had reached sufficient age to enter into the decision themselves.

Age at Time of Operation

The average age was between fifteen and sixteen years. The two youngest patients were nine years and the oldest thirty-three years. The matter of age at time of operation had an extremely important bearing on the end result to be shown subsequently.

The Operation

This was without exception the procedure described by Hibbs in his paper previously referred to. The knee joint is exposed by a transversely curved incision below the patella, deepened to the joint. The cartilage is removed from the articular surfaces of the femur and tibia. The patella is denuded of its articular cartilage and is usually entirely freed from its attachment. A groove is made in the intercondyloid area of the tibia and femur into which the patella is mortised. The periosteum of the patella is sutured across the front of the former joint line. The incision is closed with catgut sutures throughout, using chromic catgut for the skin as the dressing is not disturbed for several weeks.

Immobilization was by plaster-of-Paris spica for the first few weeks and

FIG. 1

Shows a roentgenogram of a knee that was fused for instability due to anterior poliomyelitis. Note the bony trabeculation extending from femur to tibia.

long leg plaster-of-Paris circular splint subsequently. The plaster-of-Paris dressing was applied for an average of nine months after operation. In eight cases fusion was found to be solid and support was abandoned in four months or less. A few patients wore plaster over a year, one for eighteen months.

Weight-Bearing

The patients began to bear weight at an average time of two and one-half months after operation, many of them as early as five or six weeks.

Postoperative Complications

Immediate: Wound healing in all instances was uneventful and no postoperative infections were recorded. There was one case of severe acidosis.

Remote:

Fractures. Twelve patients, or thirteen and five-tenths per cent. of the entire group, had fourteen fractures of the leg with the fused knee. These occurred from two weeks after leaving the hospital to seventeen years after operation. Seven of these fractures were through the fused area, four were in the tibia, and three in the femur. This does not seem to be a very high incidence of fracture. One would expect a leg without a knee joint to be fractured more frequently than a normal leg. These patients, for the most part, engage in little exercise more strenuous than walking, however.

Flexion deformity. A varying degree of flexion deformity was found to have developed in all but nine of the ninety patients examined. This deformity almost invariably occurs at the epiphyseal line of the tibia or femur and not through the area of fusion.

Of the eighty-one patients showing flexion deformity in the fused knee, sixty-two, or seventy-seven and five-tenths per cent., had fifteen degrees or less. The average deformity was ten degrees. This can be disregarded and in fact is, in a measure, helpful to these patients.

The group of eighteen patients with severe flexion deformity from twenty-five to forty-five or fifty degrees is quite a different matter. They are with one exception found in the younger group of patients, under fifteen years of age at the time of their operation.

Three of these patients had knee stretching under anaesthesia after operation and one of them had two of these procedures.

Twelve of these patients, sixty-six per cent., required an osteotomy to correct their flexion deformity and two of these had the osteotomy repeated because the flexion deformity recurred.

Knock-knee. There were fifteen patients who developed knock-knee deformity after the operation. This deformity was almost always associated with flexion deformity. There were three operations for correction of postoperative knock-knee.

Failure of fusion. Two cases showed failure of fusion, two and

two-tenths per cent. One of these was revised at this hospital and another was done at another hospital.

Other Operations Performed

These patients presented a fertile field for the orthopaedic surgeon. Of the ninety patients, only five definitely required but the one operative procedure, a knee fusion. The remaining eighty-five patients had, beside the knee fusions, 201 additional operations to stabilize various joints or correct deformities. This makes the total number of operative procedures for the entire group, including the ninety knee fusions, 294 or three and two-tenths operations per patient.

Follow-Up Examination

The difficulty of estimating end results in these cases of knee fusion is great, because each is rather complicated. Almost invariably each patient had had several stabilizing operations, the success or failure of which was bound to influence the functional result of the knee fusion.

The length of time elapsing between the operation and the follow-up examination was long, an average of five years and eight months per patient. Five of them were seen eighteen years or more after operation. Within this long period the patients could almost certainly tell whether the procedure had been satisfactory from their standpoint. The chief objection to the fused knee is that it is awkward to handle in a street car, subway, theater, etc. The same may be said of a brace and the fused knee liberates the patient from the services of a brace-maker.

Patients' Attitude or Feeling toward the Operation

Of the ninety patients interviewed, only nine made no comment about their reactions to the operation or none was recorded by examiner.

The remaining eighty-one patients expressed themselves definitely and their reactions are worth listening to.

Fig. 2

J. S., Case 13614. A boy rather extensively paralyzed in left upper extremity, right upper extremity to lesser degree, left leg wide-spread paralysis. At the age of fourteen, in 1920, he decided to have his left knee fused to get rid of his brace. He had had his hip flexion released in both legs previously. He is pleased with his result and is able to work as a musician. The photographs show his gait in walking.

FIG. 3

M. J., Case 15358. A patient with her paralysis confined to one leg with a flail knee. After wearing a ring-lock brace for years, she decided at the age of fifteen years to have a knee fusion. Nine months after the operation she broke the leg which necessitated wearing plaster for seven weeks. She is now a housewife who does her own work without incapacity. The photographs show how well she manages her walking with the left knee fused. Patient is completely satisfied with the result.

Seventy-four of them, or ninety-one per cent., said they were satisfied, pleased, or delighted with the operation. They felt that they had been greatly benefited. Two were doubtful and five were disappointed.

Discarding of Braces

The great majority of the patients were enabled by the operation to discard a brace which was a primary object.

Sixty-seven, or seventy-four per cent. of them, use no braces at all, while the remaining twenty-three required some support such as crutches, cane, or brace.

Difference in Length of Legs

At postoperative examination, the average difference between the sound or least affected leg and the paralyzed leg was one and three-fourths inches, which is only one-fourth inch more than the average difference before operation. It can therefore be definitely stated that the operative procedure does not materially shorten the leg.

Economic Status

A brief survey of the group from this standpoint showed:

- Forty-five patients of the seventy-six whose economic status was determined were working and financially independent.
- Thirty-one patients were dependent, among whom were many minors and school children.

The occupation of these patients has varied with their mental capabilities and as a class they have not seemed to be unduly handicapped, unless they have had too much paternalism thrust upon them and sagged beneath it.

Operative Results

These were rated from a cosmetic and functional standpoint. A good or excellent cosmetic result is one in which the patient has a solidly

fused knee with but little flexion deformity or knock-knee; and a good or excellent functional result is one which allows the patient to discard his brace, walk reasonably well with distinctly improved function.

It is quite possible to have only a fair cosmetic result with very good function. The opposite is equally possible but not so frequently.

The end results were rated as follows:

	Poor	*Fair*	*Good*	*Excellent*
Cosmetic	2	10	24	54
Functional	3	7	22	58

It will thus be seen that seventy-eight of the ninety patients, or eighty-five per cent., had good or excellent cosmetic results and eighty, or eighty-eight per cent., had good or excellent functional results, which amply justifies this operative procedure.

There were only two frankly poor end results from the cosmetic, and three from the functional standpoint.

There were ten fair cosmetic, and seven fair functional results.

Factors Having a Definite Bearing on the End Result:

I. *Extent of paralysis*

(*a*). The cases showing paralysis of only one lower extremity were eighteen in number, of which twelve, or sixty-six per cent., were rated excellent; six, or thirty-three per cent., good; in other words, 100 per cent. were good or better.

(*b*). Cases with upper extremity paralysis and paralysis of only one lower extremity were five, all rated excellent, 100 per cent.

(*c*). Cases with both lower extremities involved to a considerable degree were forty-six in number, distributed as follows:

Excellent	20	43.5 per cent.
Good	19	41.5 per cent.
Fair	5	10.5 per cent.
Poor	2	4.5 per cent.

(*d*). Cases with both lower extremities involved, one but slightly, numbered eleven, distributed as follows:

Excellent	8	72.75 per cent.
Good	2	18.25 per cent.
Fair	1	9.00 per cent.

(*e*). Cases with one or two upper and both lower extremities involved numbered ten, distributed as follows:

Excellent	4	40 per cent.
Good	2	20 per cent.
Fair	2	20 per cent.
Poor	2	20 per cent.

These ratings are a composite of both functional and cosmetic end results. It will be seen that with extensive paralysis the poorer results appear. There were eighteen cases with two flail knees in which one knee was fused. This worked pretty well if the unfused knee was somehow stabilized.

II. *Age of the patient at time of operation.* Of the twenty-three patients who were thirteen years and under at the time of operation, nine had a poor or fair cosmetic or functional result, almost forty per cent., compared with about fifteen per cent. of these results for the entire group of ninety patients. This matter of age is directly related to the factor to be discussed next.

III. *Flexion deformity and knock-knee.* Of the nineteen cases developing severe flexion deformity, twenty-five degrees or more, or knock-knee, ninety per cent. were fifteen years and younger at the time of operation, most of them under thirteen years of age. Fifteen of these cases required a postoperative osteotomy, twelve for flexion deformity and three for knock-knee.

SUMMARY

An analysis of the end results of ninety operations for fusion of an unstable knee due to anterior poliomyelitis is presented. The operation has been without risk and has resulted in no appreciable shortening of the leg. All but a small number of the patients were pleased with the end result. They were able to discard their braces and walk better. Eighty-five per cent. of them had good or excellent cosmetic and functional results. In the younger patients, thirteen years and less at the time of operation, postoperative deformity—flexion and knock-knee—is apt to occur. This is apparently due to gravity and unopposed action of the hamstrings on ununited epiphyses. Failure of fusion occurred in but two cases and was easily corrected by operative revision. The best results are obtained in those patients with paralysis limited to one leg, but the patients with both extremities involved are greatly benefited.

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OSTEOCHONDRITIS DISSECANS

A Clinical Study of Twenty-Four Cases *

BY DON KING, M.D., ANN ARBOR, MICHIGAN

The first reference in surgical literature to articular loose bodies is found in the "Complete Works" of Ambroise Paré[1]. He records that in the year 1558 he removed a loose body, or "stone", from the knee, and the patient made a satisfactory recovery. In 1738 Alexander Monro[2] advanced the theory that a free joint body might, by trauma, be derived from the cartilage covering the bone end. This explanation for the origin of articular loose bodies was accepted and the problem was considered solved. A century later, Kölliker[3] discovered living cartilage cells in the normal synovial villi. Rainey's observations[4] led to the theory that these cartilaginous cells might, under certain conditions, become free in the synovial fluid, proliferate, and form loose bodies. This plausible and fascinating theory caused the temporary abandonment of the idea of articular cartilage origin. Thirty years later, Franz König[5] recognized and described a knee-joint condition, in which it was quite obvious that a circumscribed portion of the femoral articular cartilage had loosened and fallen free into the joint. It appeared to him as though this bit of cartilage had been dissected from the condyle by a low-grade subchondral inflammatory process. He, therefore, gave it the name "osteochondritis dissecans".

During the past six years at the University Hospital we have observed in nineteen patients twenty-four such osteochondritic joints (twenty knees, four elbows). The average age of onset in our series was eighteen years, showing that it is a disease of young people. Males were affected approximately four times as frequently as females (males, fifteen; females, four) and the average duration of their subjective symptoms before appearing at the clinic was two and three-tenths years.

HISTORY

From the standpoint of the clinical history, the twenty osteochondritic knee joints fell into three fairly well defined groups. In one group were the very painful, swollen, tender joints, locked in fifteen to forty-five degrees of flexion (four cases). The appearance suggested traumatic injury. The trouble began very suddenly a few days previous, subsequent to a twist or other minor injury. There was usually no history of previous disability. X-ray examination revealed an osteochondritic focus on the medial femoral condyle, with two or three loose bodies in the joint (Fig. 1).

The second group included cases which were asymptomatic. It

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occasionally happened that a roentgenogram of the supposedly normal knee, taken for comparison, revealed a definite osteochondritic focus, without free bodies in the joints. The body or "mouse" was lying quietly in its bed on the medial femoral condyle (Fig. 2). These patients had "slumbering" osteochondritis dissecans (two cases).

The largest number of cases fell in the third group (fourteen). In this group there was a history of definite trauma in three cases. The story was of a chronically troublesome knee joint during two or three years. The complaint was a feeling of soreness, or definite pain on weight-bearing, associated with swelling. "Giving way" and stiffness were also common. These symptoms were sometimes continuous but more often intermittent, and were often associated with recurrent sudden "lockings" of the joint on arising from the sitting or squatting position. Five of this group had felt a loose body in the joint. The history of locking is similar to that which is described by patients with meniscus derangement.

The four elbow-joint cases occurred in three patients, all of whom complained of pain, stiffness, and weakness. One patient was found to have slumbering osteochondritis of the opposite elbow.

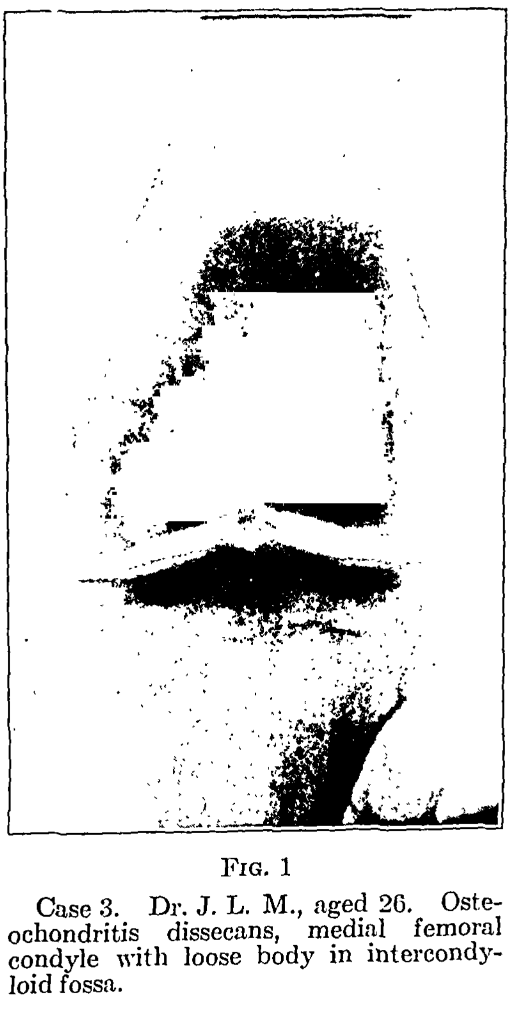

Fig. 1

Case 3. Dr. J. L. M., aged 26. Osteochondritis dissecans, medial femoral condyle with loose body in intercondyloid fossa.

Fig. 2

Case 15. L. D., aged 19. Slumbering osteochondritis dissecans, medial femoral condyle.

CLINICAL EXAMINATION

The clinical findings showed considerable variation. Slumbering osteochondritic joints and those in which the body was only partially detached not infrequently appeared normal (eight cases—thirty-three and a third per cent.). Some osteochondritic joints showed only a meager collection of fluid. Others were considerably swollen and painful to pressure, with a flexion deformity of fifteen to forty-five degrees. Such acute joints were not red, but there was detected a slight local increase in temperature. A free body was sometimes felt in the subquadriceps bursa or lateral pouches of the knee joint (three cases—twelve and five-tenths per cent.). Five of our patients had bilateral involvement; three of these were not aware of pathology in the opposite joint (two knees, one elbow).

DIAGNOSIS

In only one case did history and clinical examination alone lead to a suspicion of osteochondritis dissecans, all the rest being diagnosed by x-ray examination (Table I). It is very interesting to note that the three most

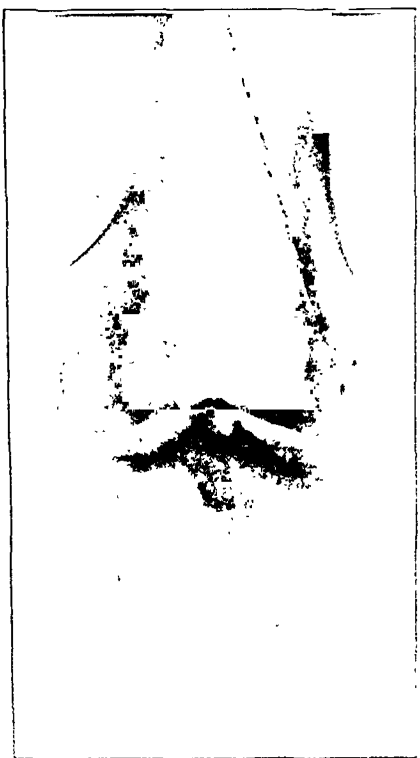

FIG. 3-A

Case 8. H. F., aged 35. Anteroposterior view of old osteochondritic knee joint with loose bodies and arthritis.

FIG. 3-B

Case 8. H. F., aged 35. Lateral view of the same joint.

FIG. 4

Case 11. E. F., aged 16. Osteochondritis dissecans of the capitulum, right elbow.

usual diagnoses in these cases were torn cartilage, tuberculosis, and loose body.

In the x-ray plate of the knee joint the process was almost always found on the postero-internal articular surface of the medial femoral condyle (nineteen of twenty cases). The entire focus appeared as a well localized, almond-shaped area of lessened density, within which was a small sclerotic mass (Fig. 1). Occasionally in the condyle at the edge of the focus there was a cystic area resembling a series of signet rings of different sizes, opening into the focus bed. The articular cartilage over the focus had a shredded appearance. Small portions (Fig. 1), or rarely the entire sclerotic mass, appeared free in the joint. Old cases coming under observation for the first time usually had several loose bodies in the joint associated with arthritis (Figs. 3-A and 3-B). Occasionally in these cases the original osteochondritic process was healed to such an extent that it could easily have been missed, all attention being concentrated on the arthritis and the loose bodies.

In our four elbow-joint cases the osteochondritic focus was found in the capitulum (Fig. 4) and certain accompanying epiphyseal changes were observed. These changes consisted in irregularity, broadening, and flattening of the radial head (Fig. 5-A). In addition to free bodies, old elbow-joint cases showed increased length of the coronoid process in front, and a thickening of the superior olecranon surface behind (Fig. 5-B).

TABLE I

? Osteochondritis dissecans	1
No diagnosis ventured	3
? Torn cartilage	3
Tubérculosis	5
Loose body	5
Gonorrhoeal arthritis, later on "functional joint"	1
Knee strain	1
? Old fracture	1
Normal joint	1
	21
Slumbering osteochondritis dissecans	3
Total	24

POSITION OF BODIES

An osteochondritic fragment discharged into a joint may become a nucleus for a rapidly growing chondro-osseous loose body. These were observed to have a great tendency to migrate to the "quiet areas" of the joint. In the knee they were especially common in the posterolateral pouch, the subquadriceps bursa, or the anterior compartment. Having once settled in these "quiet areas", they showed no great tendency to migrate. In fact, they not infrequently became rather firmly attached to the synovial membrane (Fig. 6-B). We have demonstrated them in the same situation over a long period of time. Should an attack of pain and swelling occur in a joint which contains these loose bodies, it does not necessarily mean that one of them has been caught between the joint surfaces, because x-rays taken before and after such attacks have demonstrated the bodies in exactly the same situation. Of course, such evidence is not entirely conclusive, purely chondrous bodies not being visualized in the roentgenogram. Furthermore, one of the chondro-osseous bodies may have been temporarily caught and then returned to its old resting place.

FIG. 5-A

Case 6 G. J. B., aged 21. Old osteochondritis dissecans of right elbow joint, showing loose bodies and changes in the radial head.

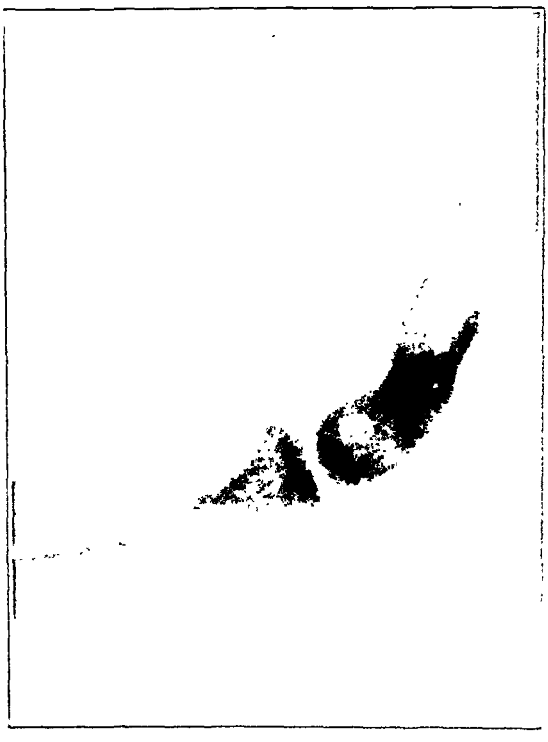

FIG. 5-B

Case 6. G. J. B., aged 21. Osteochondritis dissecans, left elbow.

Fig. 6-A

Fig. 6-B

Fig. 6-A. Case 20. C. S., aged 25. Low-power photomicrograph. Cross section through osteochondritic focus removed at operation.

Fig. 6-B. Case 20. C. S., aged 25. Low-power photomicrograph. Cross section through pedicled free body removed at operation.

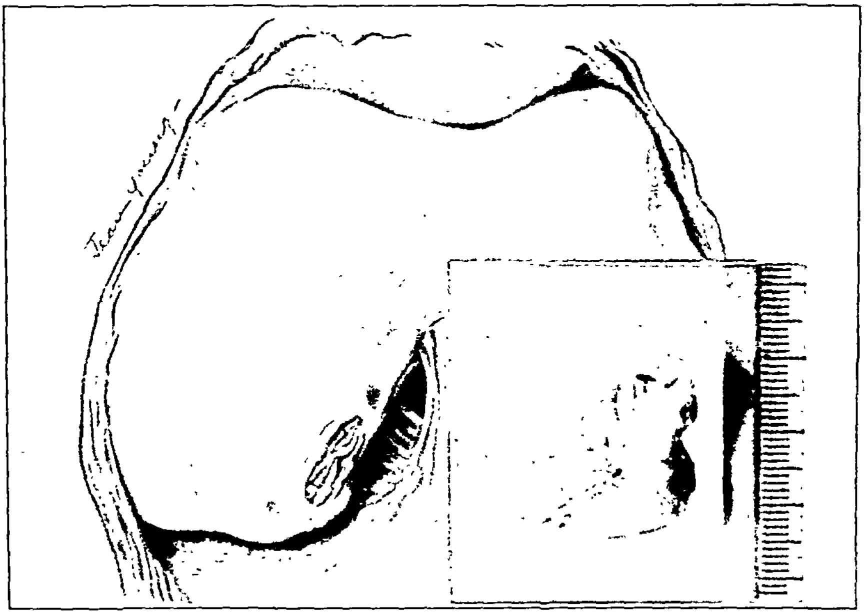

FIG. 7-A

Osteochondritic focus exposed at operation. Insert shows the same focus after removal.

FIG. 7-B

FIG. 7-C

Anteroposterior and lateral x-rays of removed osteochondritic focus. The cartilaginous covering almost completely surrounds the small bean-shaped bit of necrotic bone. A large piece of normal bone has been removed with the focus and forms the base of the specimen.

OPERATIVE RESULTS

Eighteen of our twenty-four osteochondritic joints were operated upon. On opening the joint the cartilage over the focus was found elevated above the general plane of the articular surface (Fig. 7-A). It was usually loose and its surface fissured. The body could easily be lifted out of its bed and carried with it a thin layer of osseous tissue. The bed thus exposed was not covered with connective tissue. For this study only nine cases (knee joint) were available, all others being eliminated because one year had not elapsed since operation (six cases), or because of failure to return to the clinic (three cases). Each of these nine joints had radical

removal of the focus, which implies extirpation of the body and thorough saucerization of the base, including a narrow rim of normal cartilage (Fig. 6-A). Six of the cases were between two and four years postoperative (Table II).

TABLE II

Time elapsing between operation and examination for this report:

Six years	2 cases
Two to four years	6 cases
One to two years	1 case

A patient who offered no complaint and whose joint was found to be normal, except perhaps for a little swelling, and whose check-up x-ray showed no new bodies or arthritis, was considered to have an excellent result (six cases--sixty-six and two-thirds per cent.). Two patients complained of mild weakness and stiffness especially in the mornings. On examination they were found to have chronic synovitis with pain on extreme flexion and extension. Check-up x-rays were negative except for the residual operative defect. Both of these patients before operation had had recurrent lockings associated with severe pain and weakness over periods of two and three years. Their results, therefore, were considered good (twenty-two per cent.). One patient complained of a moderate amount of pain and weakness with some stiffness and swelling. Examination showed synovitis, mild crepitus, and pain on the extremes of motion with slight limitation. He was able to carry on his work as a farmer. Before operation he had been unable to do heavy work and had several loose bodies and arthritis. He was considered to have a fair result, his residual symptoms being due to the accompanying arthritis.

It is interesting that in contrast to our study, German reports show a higher percentage of elbow-joint than of knee-joint involvement, and conclude that the least extensive operation gives the most favorable end result[6, 7, 8].

PATHOLOGY

Figure 6-A is a cross section through an osteochondritic focus (knee). The fissure in the middle of the field separates the focus (left) from a thin layer of normal cartilage and bone (right). The cartilaginous cap shows areas of partial and complete degeneration, the underlying osseous portion being less viable than normal and its base partly surrounded by newly formed fibrocartilage. A chronic low-grade productive inflammation is present, especially in the marrow spaces which are partially filled with myxomatous connective tissue. Many foreign-body giant cells are present. The picture is one of necrosis with low-grade productive, aseptic, inflammatory response.

Figure 6-B is a section through a pedicled free body. At operation the pedicle was attached to the synovial membrane overlying the crucial ligament, while the body itself was lying free in the intercondyloid fossa.

Note the long connective-tissue pedicle and its partial extension over the superior margin of the cartilaginous cortex. The hyaline cartilage is thick and healthy. On the left, at the chondro-osseous border, the cartilage continues as fibrocartilage which almost completely covers the under surface of the osseous nucleus. A mild inflammatory reaction with foreign-body giant-cell formation is present and the bony nucleus is partly necrotic.

ETIOLOGY

The cause of osteochondritis dissecans is unknown. The various theories expressed in the literature have been well summarized by Wagoner and Cohn [9] and our clinical study has not thrown new light on this subject.

SUMMARY

1. Osteochondritis dissecans occurs primarily in males in the second decade of life, and is characterized by death of a special portion of the epiphyseal nucleus and articular cartilage of the knee and elbow joints. Other joints may be affected [10,11,12]. The condition was bilateral in twenty per cent. of our cases. There is a great tendency to loose-body formation.

2. A clinical history of recurrent locking in a young man, without a history of trauma severe enough to cause a fractured cartilage, suggests osteochondritis dissecans. The diagnosis is rarely made on history and clinical examination alone; x-ray is diagnostic. The presence of loose bodies in a knee or elbow joint, whose source is not obvious, suggests a previous osteochondritis dissecans.

3. Our study of a small series of operated cases shows that radical operation gives a good result in eighty-eight per cent. of cases. Slumbering osteochondritis dissecans should be treated conservatively without operation, as spontaneous healing has been demonstrated in these cases. Long-standing cases with many free bodies and severe arthritis may not be cured by operation, because many of the subjective symptoms are due to the accompanying arthritis.

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KYPHOSIS ADOLESCENTIUM *

BY PROF. BEDŘICH FREJKA, BRNO, CZECHOSLOVAKIA

Kyphosis adolescentium was first described by Scheuermann, Copenhagen, in 1921, and in Germany it is frequently termed "*Scheuermann's Kyphose*". Mau, Sorrel and Delahaye, Grobelski, and Buchman attribute the disease to the changes in the spinal epiphyses and consider this condition to be definitely similar to the Calvé-Legg-Perthes' disease. This opinion, however, does not tally with the fact that this affection is not limited to the period from twelve to twenty-five years of age, for it is frequently observed in the first decade of life, before the epiphyses are developed.

It is not until the twelfth year, and it is usually during the fourteenth and fifteenth years, that the small toothed projections of the so called epiphyses appear in the cartilage, gradually increasing in size. At the age of sixteen, these are fully developed, both in the thoracic and lumbar vertebrae, and remain separated from the vertebral body until the twentieth to the twenty-fifth year. They are designated by Scheuermann and Mau as the special epiphyses and suggest in detail an analogy to the epiphyses of the mammalia. Although other authors regard this bone kernel as a typical epiphysis, Schmorl considers it has nothing in common with the other epiphyses of the body. The physiological function of these so called epiphyses is, according to Schmorl, to join firmly the vertebral body to the intervertebral plate, and this union is so firm that occasionally by trauma to the epiphysis a triangular section is torn from the vertebral body. On the other hand, Mau maintains his original opinion and states that the Schmorl plate is the real epiphysis, and bases his argument on its obvious phylogenetic relation to the epiphyses of mammalia.

In the development of kyphosis adolescentium, Mau distinguishes three stages: (1) the onset, which soon passes into, (2) the stage of deformity, which exists usually for a long time (two years or more) with gradual increase of the condition, and, finally, (3) the stage of reparation.

Mau considers it quite typical that this stage depends upon the period of growth, and the x-ray shows that the irregular, toothed, indistinct outline of the vertebral bodies again becomes clear, the atrophy disappears, the anterior edges of the vertebral bodies develop areas with spurs, which change in severe cases, with the result that the anterior part of the body becomes saddle-shaped. In some instances, osseous bridges develop between the bodies, which are frequently noted in the later periods, when the deforming inflammatory changes in the vertebrae begin. Mau explains the origin of this condition as due to overloading of the spine at the time when the epiphyses are developing and the blood vessels nourishing the epiphyses become injured and finally obliterated, which

* From the Surgical Clinic of Prof. J. Petřivalský

results in a necrosis of the epiphyses. Mau has succeeded in producing this experimentally in rats. *Observations also have been made on this subject* by Sorrel, Delahaye, Buchman, Grobelski, Janker, and Lyon.

Calvé and Galland have described a kyphosis accompanying the retropulsion of the nucleus pulposus, and have reported two types of cases: those without paraplegia, and those with paraplegia, the cause of which seemed to be a disturbance of the development of the primitive cord.

Schmorl explains the origin of kyphosis adolescentium by cartilaginous "knots" and originally thought that these cartilaginous knots occurred only in the adult age, and that, when the endochondreal growth was completed, disturbances could appear, with the result that the plates would be less resistant to the expansive power of the nucleus pulposus. After further observation, he places the origin at a much earlier period, and believes that the actual cause of the kyphosis adolescentium is undoubtedly a *disturbance in the development of the intervertebral discs*. Among 4000 spines, he did not find a single instance of the disturbance of the epiphysis. He observed a slight bursting out of the intervertebral plate in its pure form only in small children, but he seldom found it in the second period of development. Such asymmetries cannot be regarded as pathological phenomena, but only deviations of development within the normal physiological limits, and they assume a pathological character only from the effect of overloading. These changes show themselves as round or toothed projections of the intervertebral plate into the bone tissue in the places where the slipping is most pronounced. With the overloading, the tissue of the nucleus presses into the openings of the body, causing an atrophy of the bone beams in this vicinity, which often penetrates into the spongiosa. Further progress in the bone is stopped by reactive changes in this vicinity which result in a sclerotic condensation and a walling off of the knot. These small furrows in bone Schmorl considers as characteristic of kyphosis adolescentium. They differ from the changes in osteoporosis, in which they are usually limited to the region of the nucleus pulposus, and as a rule appear only in one vertebra. Schmorl explains the origin of the kyphosis by the disproportion that exists between the resistance of the intervertebral plate and the weight, and, according to him, this condition can originate only in the period of adolescence. He is convinced that his theory explains the fact that kyphosis can develop quickly as the result of the sudden overloading of the spine; it develops especially in farm laborers who work in bent positions and also it can develop gradually as the result of moderate trauma. All of this coincides with the clinical experience, that physical exercise exaggerates the condition and is contra-indicated.

In spite of the authority of Schmorl, the author does not think that this thoroughly explains all the phenomena which accompany kyphosis adolescentium. It fails to explain the blurred outlines of the anterior part of the vertebrae in the early stages of the affection, and does not explain the typical cycle lasting two or three years, so well described by Mau. It is evident that this same change must be explained, when it occurs in the

course of a definite disease, such as acute and chronic inflammation, and particularly in tuberculosis, and it is not surprising that Calvé in 1922, and Buchman in 1925, considered this condition to be a mild infection of the epiphysis.

In the Clinic of Prof. Petřivalský of Brno, the author has had the opportunity of studying three cases, which indicate the direction of further research.

CASE 1. A boy, sixteen years old, pupil in secondary school, healthy, strong, and well developed.

Family history: Tuberculosis in a cousin of the mother at twenty-five years. One brother of the father died of tuberculosis at age of twenty; another died in ninth year with "typhus," which was said to be accompanied by persistent fistulae on the face. Sister of father died of inflammation of cerebral membranes. Only one brother of the father was living and well. From the age of forty the father had had a form of catarrh, was pale, anaemic, thin; from 1916 to 1920 he had had a purulent and persistent inflammation from the middle ear.

The patient himself had had some form of catarrh from the age of four, when he had scarlet fever and diphtheria, followed by persistent cough, and complicated by double inflammation of the ear, with discharge. Since this period there have been frequent attacks of angina and catarrh. At the age of eight he had a tonsillectomy which resulted in improvement for only about a year and a half; between eight and ten, he had a return of the catarrh and of the middle ear, followed by defective hearing, and blepharitis. Later he developed pleurisy and was treated by heliotherapy at the sea. At the age of fourteen, he had another attack of pleurisy and at this time developed a strongly positive

FIG. 1

Case 1. Lateral roentgenogram.

FIG. 2

Case 1. Anteroposterior roentgenogram.

von Pirquet reaction. No involvement of the spine was detected, but, from the age of eight, there was a disinclination to exert himself, to take long journeys, or to play, and a very marked tendency to rest recumbent. There was always *a disinclination for any exercise involving spinal strain.* This was in sharp contrast to an active mental development.

The clinical condition then improved. In 1928 the patient became more resistant to infections, began to swim, and the reluctance to exertion disappeared, but there remained a definite rounded kyphos of the spine. The condition at present shows a marked dorsal kyphosis, rigidity of the entire thoracic region, but no sensitiveness. X-ray, lateral view, shows *a typical picture of Scheuermann's kyphosis.* The vertebral bodies are wedge-shaped, particularly in the anterior portion, with irregular toothed outlines. The trabeculae in the anterior part of the bodies apparently have been rebuilt; the outlines are unevenly toothed, but they are distinct, and in some areas show a distinct sclerotic condensation. The anteroposterior view, focused on the eighth dorsal vertebra, shows the area *from the seventh to the ninth thoracic vertebrae screened by the dense* shadow; the intervertebral plates are scarcely visible; along both sides of the spine there is a dense shadow of an abscess, which ends sharply in a pear-like shape, on the right of the eleventh dorsal vertebra. The spine shows a lateral deviation in an S curve, with the deviation to the right of the upper portion, and with the apex at about the eleventh thoracic vertebra.

On examination of this patient one and one-half years ago, the first indication for treatment was to consider the patient as having a spondylitic abscess, but the sedimentation test and von Pirquet reaction were both normal. Prof. Teyschl, who formerly treated this patient during the acute stage of the illness, stated that at that time, the tuberculous reactions were distinctly positive. The following treatment therefore was decided upon: the avoidance of gymnastics, with the exception of breathing exercises and swimming; restricted activity, particularly that incurring physical exhaustion; no apparatus or recumbency was ordered. Today, after one and one-half years, the condition of the patient is good, the spine is rigid as formerly, otherwise the patient is healthy, strong, and sunburned and has no symptoms. The defect of the spine has not increased.

Case 2. Girl, thirteen years old, pupil in secondary school.

Family history: Father gave history of pulmonary tuberculosis, with hemoptysis, for a number of years. Mother had had gastro-intestinal disturbance.

The patient at early age was apparently strong and well. At the age of three the child had whooping cough, after which the parents observed that the posture was not normal; there was no pain. The patient carried on gymnastic exercise for one year, which improved the condition, after which she was discharged as cured. At the age of six she had chickenpox; at seven, scarlet fever; at eight, measles; at nine, influenza and scarlet fever, followed by nephritis; at ten the parents noticed that the child's posture was incorrect and that she did not walk straight, but the defect was comparatively slight, and no attention was given to it. At the age of twelve a gymnastic teacher called attention to the fact that the defect was increasing, and the patient was sent to be examined.

Examination showed the patient healthy and well developed, strong and tall. The von Pirquet reaction was negative. The dorsal spine showed a kyphos, with the summit of the curve between the eighth and ninth dorsal vertebrae, with rigidity between the second and eleventh vertebrae, but no sensitiveness.

Roentgenogram, lateral view, shows a moderate posterior curve, the thoracic vertebrae slightly wedge-shaped, the most marked changes in the eighth and ninth dorsal vertebrae. In the vertical plane the body of the eighth vertebra is twenty millimeters in the anterior, and twenty-six millimeters in the posterior portion; the anterior portion is slightly saddle-shaped. In the anterior portion of the intervertebral disc is a small bone shadow corresponding to the appearance of a developing epiphysis. The body of the ninth vertebra is twenty millimeters in height in the anterior, and twenty-nine

Fig. 3

Case 2. Lateral roentgenogram.

Fig. 4

Case 2. Anteroposterior roentgenogram.

millimeters in the posterior portion; concave and saddle-like in the anterior portion, and shows in this area, six millimeters from the margin, a tooth-like projection three millimeters in depth; the margin of the vertebra shows condensation. The tenth and eleventh vertebrae anteriorly are normal, broad, slightly saddle-shaped, and the anterior portion of the body slightly pointed. The outlines of the bodies are clear and distinct. In the anteroposterior view, the spine shows a slight S curve on the left opposite the ninth and tenth vertebrae, and the upper portion of the curve is from the sixth to the seventh dorsal vertebrae. The plates between the seventh and eighth, and eighth and ninth, and also between the ninth and tenth are less distinct than between the other three vertebrae, and the spine in this area shows a lack of clear outlines. At the right side of the spine, from the ninth to the tenth vertebrae there is a slight shadow, three to four millimeters broad, ending sharply at the height of the diaphragm. In the upper portion, this shadow disappears gradually at the level of the ninth dorsal vertebra. This cannot be designated for a certainty as a spondylitic abscess, but corresponds to the appearance of an abscess which probably existed sometime previously. It is possible that the slight indistinctness of the eighth and eleventh vertebrae has been caused by the fibrous tissue which has developed in the area of the original tuberculous process. The x-ray is not a typical illustration of Scheuermann's kyphosis, although clinically the affection cannot be distinguished from the kyphosis adolescentium, and the process is quite typical. The patient was treated by orthopaedic gymnastics, with an improvement of posture in a comparatively short period. Nine months later the patient still practises gymnastic work daily, is in good condition, and the defect is not particularly noticeable, but the spinal column remains rigid.

Case 3. Woman, twenty-eight years old. Family history good. The woman was well until February 1922; was then obliged to have some special treatment after an attack of influenza; in June came for consultation in regard to constant pain in upper dorsal

vertebrae. The spine, as shown by anteroposterior view, appeared normal; the patient remained under treatment until the end of July 1923; there was strong positive tuberculous reaction. The case was treated as one of tuberculosis, but repeated x-rays of the dorsal spine were negative. The patient was employed as a secretary, using a typewriter, and after a particularly busy period, symptoms increased and she was unable to hold herself erect, but after a week of rest, the pain disappeared. At the end of October 1923 her condition was so good that she was given permission to marry. No ill effects followed the birth of a child in 1925, and symptoms did not reappear until January 1926, when the general condition was very much depleted by nine months of nursing, and at this time she began to have pain in the back, which disappeared after a rest. Following this there was occasional reappearance of pain, particularly after overwork, but with improvement after rest. X-rays at this period showed no change in the spine. The condition remained practically the same, with occasional relapses of pain and sensitiveness, but with recovery; increased at one time when living in a damp area. In 1929 the patient had an attack of influenza, after which pain returned and persisted.

Examination at present shows the patient in apparently good condition, with increased weight. She has a child of five years, who shows considerable swelling of glands, but otherwise is apparently healthy.

The woman complained of muscular pain in back, and showed on examination a rigid spine, with moderate degree of rounded kyphosis; there was no sensitiveness of spine; von Pirquet reaction was strongly positive, both in the mother and the child.

Roentgenograms in lateral view show moderate backward curve; the vertebral bodies are somewhat wedge-shaped, and the anterior surface saddle-shaped with margins projecting, with rather prominent sclerotic condensed edges; the vertebral bodies and the intervertebral discs are well preserved, except that the body of the seventh and adjacent parts of the sixth and eighth vertebrae show a reforming of the trabeculae, and

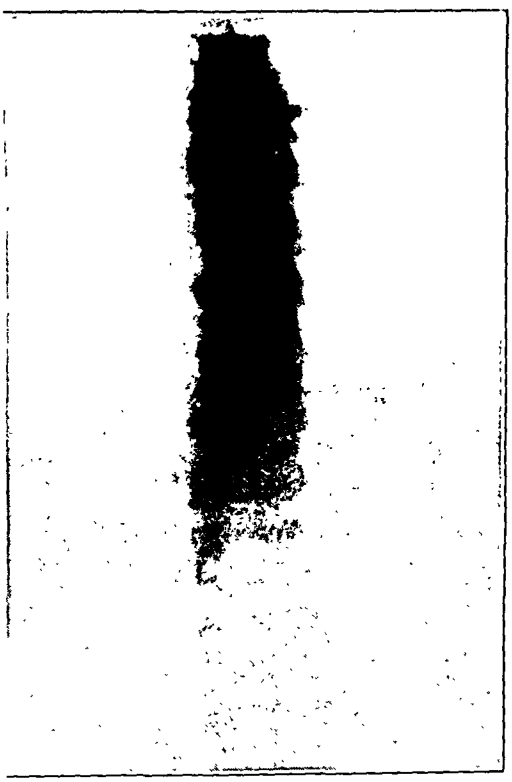

FIG. 5

Case 3. Anteroposterior roentgenogram.

FIG. 6

Case 3. Lateral roentgenogram.

the intervertebral discs in this area are hardly visible. The margins of the seventh vertebra are the most prominent. The anteroposterior view shows from the seventh to eleventh dorsal vertebrae a loss of contour of the vertebral bodies and the intervertebral discs hardly visible, blurred by a shadow; a lateral S curve, with deviation toward the left, at level of the eighth dorsal, and with the compensatory curve toward the right of the level of the twelfth dorsal vertebra. On the right of the dorsal spine, between the seventh and tenth vertebrae, is a faint oblong shadow, from five-tenths to one centimeter in width, which at the level of the tenth vertebra fuses with the shadow of the spine and merges with it. The lungs show an old cured process of tuberculosis.

The roentgenograms do not show the typical findings of Scheuermann's kyphosis, but are cited only as evidence that a long-lasting and rather undetermined affection of the spine can result from an infection of tuberculous origin, the existence of which cannot be doubted. At present the tuberculous process in this patient is still active, and she is still under local and general hygienic treatment; she is having slight pain in the back only in the morning, and but few symptoms during the day; she is not able to do heavy work.

DISCUSSION

In the foregoing cases there is undoubtedly tuberculous involvement of the spinal column. These cases show the condition in patients of different ages: the first, in whom the illness began at the eighth to the tenth years and, who, at the age of sixteen shows complete cure; the second case, a girl in whom the condition developed between the fourth and sixth years and who at the age of thirteen is cured; and the third case, a woman of twenty-eight, in whom the condition developed seven years ago and is now in the stage of reparation, not quite complete. The onset of the condition in these cases has no relation to the development of the vertebral epiphyses.

The x-ray findings in the first case are identical with pictures of Scheuermann's and show added shadows of an oblong abscess, which completes the picture of the tuberculous process. In the second and third cases, the findings are rather unusual for a round back, and in the third there is evidence of the vertebra being affected by tuberculosis.

In the comparison of these round backs with the findings in bone and joint tuberculosis, it is seen that these cases, as well as those reported by others, support the theory of the gradual development of bone and joint tuberculosis. According to Mau, in the newly rounded backs, the outlines are indistinct and blurred; after about two years the outlines of the vertebrae become more distinct, but are uneven and toothed; and finally in the cured cases, the toothed outlines show a condensed and sclerotic appearance with a partial elimination of the uneven surfaces.

The question is as to what form of tuberculosis may result in these changes.

It is evidently not the usual form which is seen, described as Pott's disease, for during the usual course of this affection, there is a beginning destruction and disappearance of the intervertebral discs. On the other hand, in the cases of kyphosis described above, the intervertebral plates remain preserved, and merely become somewhat narrower, particularly in their anterior portions. The x-ray shows the presence of the tubercu-

lous abscess, situated in the anterior portion of the vertebral bodies under the anterior ligament, an abscess which, in contrast to the usual forms of tuberculosis, does not penetrate as far as the vertebral bodies and the intervertebral discs, but remains on the surface and shows itself externally.

In the writings of Schmorl, or during the author's inspection of Schmorl's large collection, he was unable to find any condition which would correspond to this picture.

In Ménard's work in 1900, there are given illustrations of spinal columns in which a tuberculous abscess spreads from the site of the affected vertebra a considerable distance in both directions, along the anterior portion of the spine, eroding only the surface of the vertebra, not penetrating into its structure, and not disturbing the intervertebral discs.

The course of the affection in our cases is typical, and suggests a relation to this form of tuberculous disease. In the early period, the patient suffers sometimes from slight back pain, and again the disease manifests itself only as marked malaise, and an unconscious avoidance of physical effort, and by exhaustion after even moderate exercise. The examination of the spine at this period by x-ray shows practically nothing, which is to be expected because of the fact that the involvement is more of the soft parts, and has not yet affected the bone.

Clinically, the period of slight pain lasts about two years, during which time there is gradual development, as seen by the x-ray, of the conditions described by Scheuermann and Mau as the first stage of the stiff round back. The outlines of the vertebrae become indistinct, as is found in the earlier tuberculous processes, more pronounced in the anterior portion, and gradually penetrating into the body in different degrees. Only later, according to Mau, is found the period of deformity, and later the stage of recovery, which stage is, in cases of tuberculosis, the period of repair, and finally of healing. The tuberculous process on the anterior portion of the spine becomes quiescent, is absorbed, leaving only a cicatricial area, and there is no reason to expect a return of the mobility of the spine.

As regards the origin of the tuberculous process in the anterior portion of the spine it is not possible to give an explanation. In the third case, with an active tuberculosis of the lungs, it may possibly have been an extension of the process by contiguity.

It is also difficult to explain or to give a definite opinion in regard to the final condition of the spine in these cases, and sometimes there is a resemblance to the kyphos of Bechtěrev's disease, in which Marie and Leri found in anatomical specimens the anterior ligament ossified from the sixth to the twelfth vertebrae, and an ankylosis by a narrow area of bone along the anterior portion of the spine. There is also ossification of the ligaments between the spinous processes on the apex of the curve, and, in addition, areas of bone proliferation between the vertebrae, but which do not unite. Leri considers that this form of kyphosis appears after injury, in which the blow results in a straining of the anterior ligaments, following

which the ossification begins in the ruptured portions of the ligament. The final result is analogous to the condition in the paravertebral abscess, which also results in complete rigidity of the spine, with the rounded kyphos.

Meyer and Janker have found illustrations of the kyphos with the sclerotic outline of wedge-shaped vertebral bodies, but with no ankylosis in the anterior portion. It is possible that the milder cases of this affection show this final result.

As a whole, the cases described are interesting from a twofold point of view, showing first, that one of the causes of the "round, stiff back" may be tuberculosis; and second, that an inflammatory process of tuberculosis of the spine may pursue a mild course for a long time, without definite clinical or x-ray evidence, and the actual condition may not be demonstrable until after a period of several years.

It is obvious that all cases of round stiff back cannot be explained as due to a latent tuberculosis, for this is only one of the causes. Especially has it been demonstrated in recent years by Italian authors that the disturbances of the hypophysis can also produce the clinical picture typical of ykphosis adolescentium.

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EXCISION OF HEMIVERTEBRAE FOR CORRECTION OF CONGENITAL SCOLIOSIS

Report of Two Cases *

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Congenital scoliosis is usually associated with a developmental abnormality in one or more of the vertebral bodies. The commonest change noted is that of asymmetrical development of the corresponding halves of the deformed vertebrae. This may vary from wedging to complete bifurcation of vertebral bodies into hemivertebrae with one half larger than the other, or complete absence of a corresponding half, or the interposition of one or more half vertebrae which are entirely accessory or supernumerary. These deformities cause a lateral deviation of the spine similar to that which would occur if a wedge were inserted between the lateral edges of a stack of a child's blocks. The additional factor of rotation which is seen in the older cases of scoliosis may not at first be present, since the dorsal convexity and lumbar concavity of the spine become obvious only after the upright position is assumed. Spina bifida is frequently present and may complicate any attempt to correct the deformity.

In 1926 Kleinberg[1] stated, "a curvature of the spine due to some congenital malformation of the vertebrae or ribs is incurable. The author has seen and treated a comparatively large number of congenital scolioses. He has used different methods in treating them, but has never seen any case permanently improved. Nor is this to be wondered at if one realizes that we have no means in the present state of our knowledge of either removing or correcting the cause,—namely, the malformation." This statement expresses the general consensus of opinion.

In a search through the literature it was found that Royle[2] had mentioned briefly the successful removal of part of a wedged vertebra in a child two and a half years of age, but no other report of a similar operation was found. Codivilla[3] in 1901 had suggested a similar operation, but the procedure was rejected as too dangerous.

In the cases here reported we were successful in removing hemivertebrae and in correcting the curvature of the spine.

Case 1. B. M., female, colored, was first seen when thirteen months of age. She was thought to be entirely normal until at the age of six to eight months, after she had begun to sit up, the mother noticed that the back curved (Fig. 1). The curvature slowly progressed and, when she began to walk at the age of twelve months, the deformity became quite noticeable. There was nothing to suggest the presence of spina bifida. An examination revealed a very well nourished, well developed, intelligent, and alert baby, with a rather acute left scoliosis curve at the dorsolumbar level. No other abnormalities or abnormal physical findings were noted.

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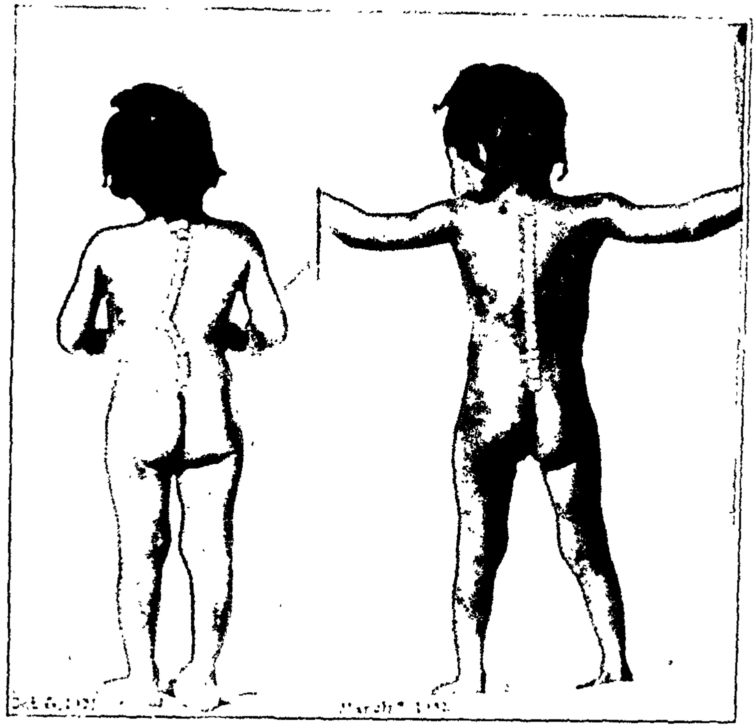

FIG. 1

Case 1. B. M. These photographs illustrate the appearance of the patient before operation and four and one-half months after excision of the hemivertebrae. The flare of the ribs on the left side of the chest, as well as the sharp curvature of the spine, has disappeared.

The father, aged thirty-six, and the mother, aged twenty-six years, were living and well. An older child was quite normal. No history of congenital deformities in any of the relatives of the child could be obtained.

Wassermann and Kahn tests were negative for the patient and for both parents. Neurological and blood cytology studies were entirely normal.

The x-ray examination (Fig. 2-A) revealed a congenital abnormality in the cervical region from the fifth cervical to the second thoracic vertebrae with spina bifida. Eleven dorsal vertebrae were present on the right side with fusion of the right tenth and eleventh ribs. Twelve ribs and twelve vertebrae were present on the left side. There were six vertebrae in the lumbar area on the left and five on the right side. The scoliosis at the junction of the thoracic and lumbar vertebrae with the curvature to the left was quite marked. The eleventh dorsal vertebra consisted of a left half only, while an accessory hemivertebra was wedged between the twelfth dorsal and first lumbar vertebrae on the left side, the two causing the sharply angled scoliosis.

OPERATION

The operation on October 12, 1931, was performed under ether anaesthesia.

A curved incision was made, extending from the eighth dorsal to the third lumbar vertebrae. The tips of the posterior spinous processes were identified and the prespinous fascia was incised. Using a blunt periosteal elevator, the left sides of the spinous processes and the corresponding laminae were bared. The erector spinae muscles were reflected laterally, and the transverse processes of the eleventh and twelfth dorsal and the first and second lumbar vertebrae were brought into view. These were quite small and were easily broken off with the periosteal elevator.

An incision parallel to the eleventh rib on the left side was now made, connecting with the longitudinal incision and extending laterally to the left for a distance of ten centimeters. Using a small rib stripper, the eleventh and twelfth ribs were denuded of all soft-tissue attachments. The twelfth rib was removed and a segment of the eleventh rib, six centimeters in length, was excised.

The column of spinal muscles was now retracted medially and the laminae and pedicles of the vertebrae from the eleventh dorsal to the second lumbar were exposed. Using the periosteal elevator, the parietal pleura was carefully dissected from the bodies of the lower dorsal vertebrae and the bodies of the eleventh and twelfth dorsal and first lumbar vertebrae were exposed laterally and anteriorly, so that the finger could pass

FIG. 2-A FIG. 2-B FIG. 2-C

CASE 1. B. M. The multiple congenital anomalies are well demonstrated in the roentgenogram Fig. 2-A. Hemivertebrae *a* and *b* are acting as wedges to produce the marked lateral curvature.

Fig. 2-B. Illustrates the x-ray appearance of the spine after excising most of the hemivertebrae *a*' and *b*'. Since the laminae were not removed and some fragments of the vertebral body remained attached to the cartilage-lined space, the full defect left in the vertebral column is not adequately demonstrated.

Fig. 2-C. The curvature of the spine has been improved.

completely around them. Care was exercised to avoid unnecessary trauma to the nerve roots, but the lateral lumbar veins were clamped and tied. A small tear in the pleura was plugged with a piece of muscle and the complete excursion of the lung could be readily demonstrated through the thin transparent pleura.

With a small chisel and a dissector the left eleventh dorsal hemivertebra was removed in several fragments of from three-tenths to one centimeter in diameter. It was possible, through the defect thus created, to palpate the dura. The left half of a vertebral body was removed from the level of the first lumbar vertebra, leaving a cartilage-lined defect. The corresponding laminae were only partially excised.

During this stage of the operation the patient was in mild shock and the radial pulse could not be palpated. The aortic pulsation, however, was easily obtained, was of good quality at all times, and varied in rate from 130 to 160 per minute. It was now possible, by exerting some pressure at the apex of the scoliosis curve, to obtain some degree of correction, but no attempt was made at this time to maintain the correction.

The muscles were sutured with plain catgut across the pleura and the defects created by the rib excisions.

The spinous processes and laminae on the left side were again exposed, roughened with a chisel, and curls of bone were turned laterally across the articular facets. The ribs which had been removed were split longitudinally and placed as grafts on the laminae, extending from the eighth dorsal to the third lumbar vertebrae.

Immediately after closure of the wound a transfusion of 350 cubic centimeters of citrated blood was given very slowly into the external jugular vein.

Convalescence was uneventful. The wounds were permitted to heal and sutures were removed before beginning forced correction. A plaster jacket was applied such as that described by Hibbs, Risser, and Ferguson [1] for scoliosis, including the left leg and body, and extending to the right side of the head. Hinges were incorporated in the cast anteriorly and posteriorly, with the axis placed directly over the twelfth dorsal vertebra. The cast was cut completely around at this level, an elliptical portion of cast was removed from the left side, and a turnbuckle was inserted on the right side of the cast. By gradually opening the turnbuckle, satisfactory correction was obtained over a period of three weeks, and this correction was maintained by removing the turnbuckles and filling in the cast with plaster.

X-rays of February 22 and March 16, 1932, showed definite correction (Fig. 2-C).

Microscopic sections of the fragments of the hemivertebrae show normal cancellous bone and normal marrow elements, to which is attached fibrocartilage. The patient is now ambulatory in a plaster jacket which includes the shoulders and pelvis.

CASE 2. W. H., a white male, aged sixteen months, was admitted to the Hicks-McElwee Orthopaedic Hospital, December 8, 1931, for treatment of congenital deformities of the spine. He had been followed in the out-patient clinic since July 8, 1931.

Two weeks after birth of the patient, the attending physician told the parents that the spine was crooked. The curvature extended to the right, and the lumbar spine was curved posteriorly. The deformity gradually became more marked, and when the child began to try to sit up he slumped forward as though there were very little support from the lumbar vertebrae (Fig. 5-A). Roentgenograms which were taken two weeks after birth showed multiple abnormalities with bifid vertebrae and asymmetrical development of lateral halves (Fig. 3).

Examination following admission to this clinic revealed a right lateral scoliosis extending from the second dorsal to the third or fourth lumbar vertebra. The spinous processes of the second, third, and fourth lumbar vertebrae were quite prominent.

The blood Wassermann and Kahn tests of the father were positive (++++) and those of the mother were negative in repeated examinations, while the patient had a slightly positive reaction. Two subsequent tests of the blood of the patient were entirely negative.

X-ray examinations showed multiple congenital anomalies of the spine, with a wide,

rounded scoliosis curving to the right. There was failure of fusion of both the bodies and the laminae in the lower thoracic and in the lumbar regions of the spine. The scoliosis could be accounted for by the normal development of the right halves of the vertebral bodies, while the left halves of corresponding vertebrae were markedly underdeveloped, creating a curve with its convexity to the right. Rotation of the vertebral bodies was not marked. The greatest asymmetry in the development of the lateral halves of the vertebral bodies was noted in the first lumbar vertebra (Fig. 4-A). Although the patient was only sixteen months of age, excision of the large right half of this body and fusion of the bodies of the second and third lumbar and eleventh and twelfth dorsal vertebrae on the right side were advised.

OPERATION

The operation on December 14, 1931, was performed under ether anaesthesia. A curved incision was made just lateral to the tips of the spinous processes and extended from the level of the sacrum to the tenth thoracic spine. The right side of the spinous processes and laminae was bared by subperiosteal stripping. The right transverse processes of the first, second, and third lumbar vertebrae were fractured, and the right twelfth rib was excised. The bodies of these vertebrae were then exposed by carefully dissecting with a periosteal elevator from the base of the fractured transverse processes laterally and anteriorly.

Fig. 3

Case 2. W. H. The anterior-posterior roentgenogram of the spine, taken two weeks after birth of this patient, demonstrates the multiple anomalies and defects which were present. Note the lateral curvature and the asymmetrical development of lateral halves of the bifid vertebral bodies.

The sharply angled lumbar kyphos is well demonstrated in the lateral view of the spine.

Fig. 4-A

Case 2. W. H. The appearance of the spine at the age of sixteen months is quite similar to that noted soon after birth. The first lumbar vertebra a is apparently acting as the principle wedge which produces the curvature.

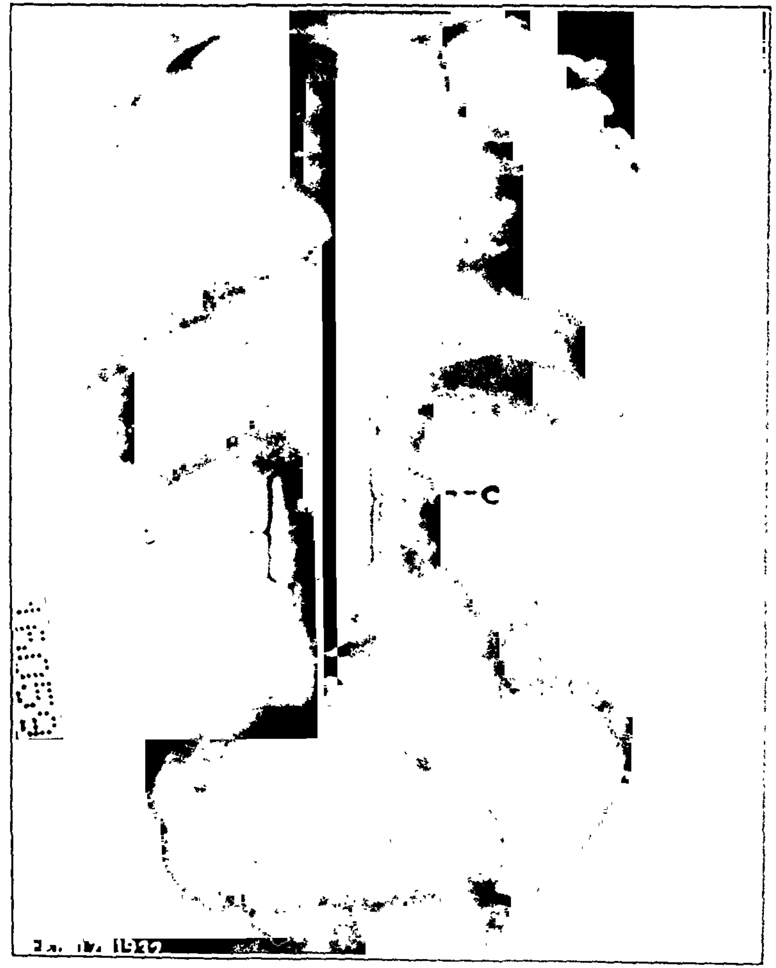

Fig. 4-B

Following the excision of the hemivertebra a, the curvature was corrected as shown in the second roentgenogram which was taken two months after operation, February 12, 1932. The tibial grafts b, placed in a groove on the sides of the vertebral bodies, are well demonstrated, but the rib grafts c on the laminae are not so easily seen.

FIG. 5-A FIG. 5-B

Case 2. W. H. Before operation the patient was not able to support himself. The telescoping collapse of the spine when sitting is illustrated in the first photograph. The second photograph, made two months after operation, shows marked improvement in alignment of the tips of the posterior spinous processes.

Using a curved gouge, the right half of the first lumbar vertebra was excised, leaving a cartilage-lined cavity. The corresponding pedicle, articular facet, and lamina were also removed with a bone-biting forceps. It was now possible to close the defect created by removal of this hemivertebra by exerting gentle pressure on the adjacent vertebrae.

An osteoperiosteal bone graft was removed from the left tibia and inserted in a groove gouged in the bodies of the vertebrae from the third lumbar to the twelfth dorsal inclusive. The twelfth rib which had been removed early in the operation was now split lengthwise and placed as a graft on the laminae at the right side of the base of the spinous processes of the eleventh thoracic to the third lumbar vertebrae.

On the fourth postoperative day a body cast was applied, including the head and the left leg. The hinges were placed, anteriorly and posteriorly, so that the axis lay opposite the twelfth dorsal vertebra. By means of a turnbuckle placed on the left side the curvature was corrected.

For fifty-eight days after operation there were no complications. He voided regularly, although he had never been trained, and urine was not collected. Bowel function was normal. On February 10, 1932, he developed an acute retention of the urinary bladder with vomiting and an associated febrile reaction of 38.8 degrees, centigrade. A catheter was passed and 350 cubic centimeters of clear urine were obtained. The phimosis was so marked that the smallest catheter had to be used and it was impossible to retract the foreskin sufficiently to expose any portion of the glans. Following the decompression of the bladder the temperature became normal, the gastric symptoms disappeared, and the patient was entirely comfortable.

A neurological examination revealed no abnormal findings with the exception of the absence of the left ankle jerk. Pressure on the spinal cord from the [illegible]

incarceration of nerve roots in scar or callus would seem to be the logical explanation of the urinary retention.

Upon the advice of the neurological and urological consultants the patient was catheterized twice daily. He is now voiding spontaneously and catheterization has been discontinued. Roentgenograms of February 12, 1932, showed satisfactory correction of the curvature of the spine. The patient is now walking, wearing a full-length body cast.

CONCLUSIONS

1. The standard methods used in the treatment of acquired curvatures of the spine are not adequate for the correction or the prevention of scoliosis which results from congenital anomalies of the spine.

2. Two cases are reported in which nearly all of each hemivertebra was successfully removed with marked correction of the spinal curvature.

3. Since the deformity in these cases is usually progressive, due to the more rapid growth of a number of the asymmetrically developed vertebrae, fusion of the lateral halves of two or more of the vertebral bodies on the convex side of the curvature to check the rate of longitudinal growth would appear to be a rational and justifiable procedure.

4. The fusion of vertebral bodies rather than laminae in the treatment of certain cases of other types of scoliosis in growing children has been suggested.

5. Final judgment of the efficacy of the procedure described cannot be given until many years have elapsed.

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OSTEO-ARTHRITIS DEFORMANS CONTRASTED WITH OSTEO-ARTHRITIS DEFORMANS JUVENILIS *

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The comparative study of the adult and juvenile types of osteo-arthritis deformans must be based upon the anatomical and histological changes present in the two types of this disease.

Osteo-arthritis deformans is a chronic non-infectious, proliferative inflammation that leads to a deformity of the joint structures (Fig. 1). The development and presence of marginal exostoses have always been of especial importance for the anatomical as well as the histological diagnosis of arthritis deformans. These marginal exostoses are characteristic and constitute the decisive feature for the diagnosis of this disease (Fig. 2). The exostoses arise as the result of vascularization and ossification which, beginning in the subchondral marrow spaces, invade the overlying non-calcified cartilage. This vascularization and ossification follow the loss of elasticity of the joint cartilage and comprise the first definite diagnostic features of arthritis deformans (Pommer) (Fig. 3).

These marginal exostoses are not ossified excrescences (Volkmann), or periosteal or perichondrial proliferations or osteophytes (Nichols and Richardson), or periosteal lippings (Kimura, Ziegler); they are (as Pommer maintains) bone formations, that, arising from the

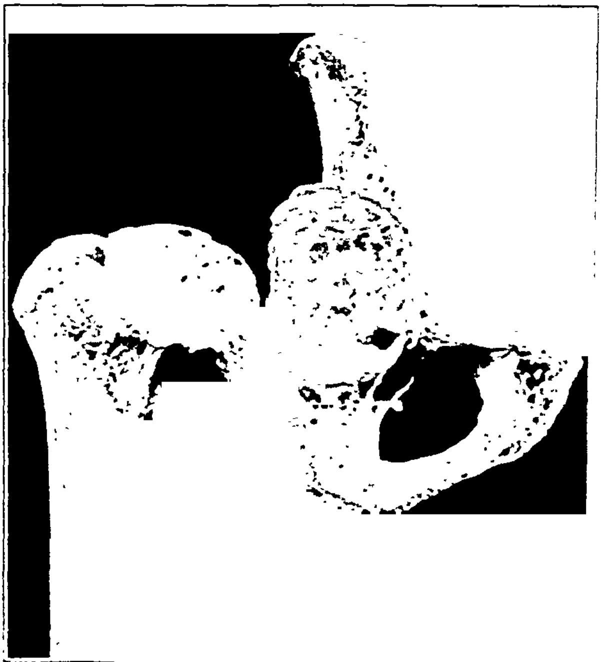

FIG. 1

Arthritis deformans of a hip joint, showing characteristic lesions. Macerated specimen.

* Read before the College of Physicians of Philadelphia, November 4, 1931 (Mary Scott Newbold Lecture).

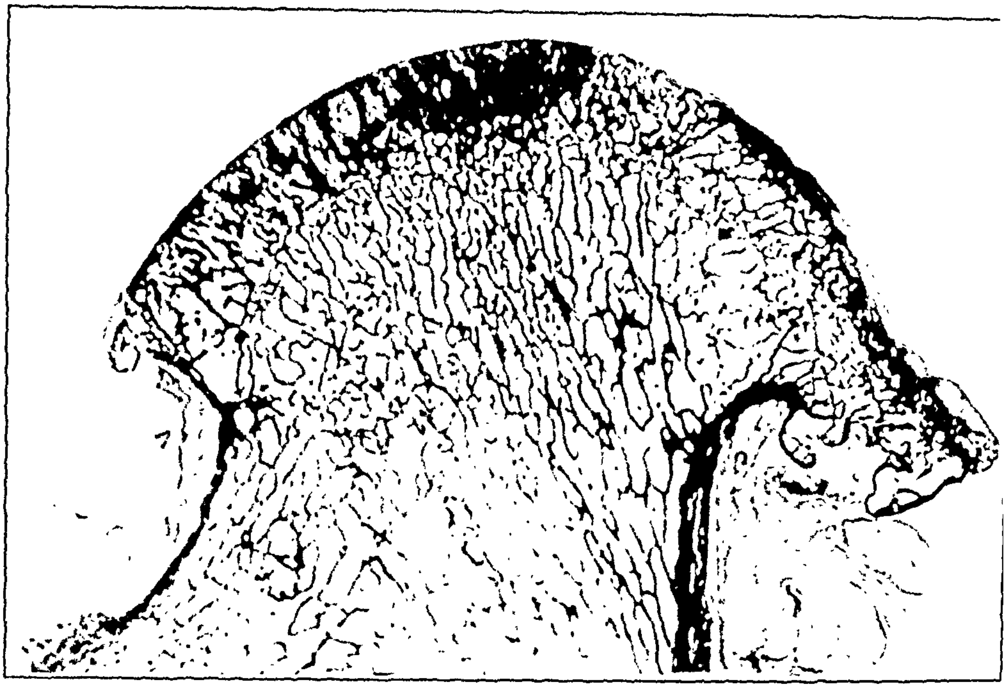

Fig. 2

Head of the femur in arthritis *deformans* with marginal exostoses. (Microscopic section.)

subchondral marrow tissue, grow out into the joint cartilage. The possess a laminated structure, are united to the spongiosa (Fig. 2), an are usually covered with new cartilage.

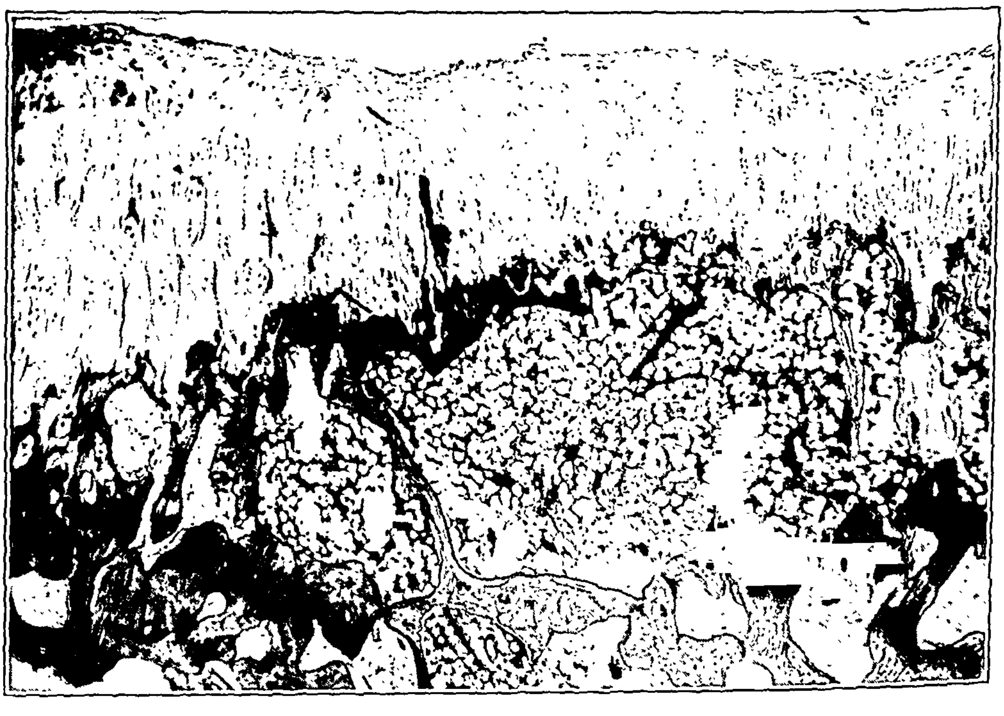

Fig. 3

Vascularization and ossification of the basal cartilage following alterations of the superficial layers of the joint cartilage. (Hip joint of a fifty-three-year-old man.)

The joint cartilage presents various alterations, chief among which are alterations in consistency associated with a splitting of the ground substance (Fig. 3). These alterations disturb and damage the elasticity of the cartilage. These alterations in the physical and structural characteristics of the normal articular cartilage first appear at those sites of normal transition of hyaline cartilage into fibrous cartilage. Anatomically, the most common locations for these changes are about the margins of the fovea and at the junction of the femoral head and neck (Lang, 1924).

Fig. 4
Separated joint cartilage lying deep within the spongiosa. (Arthritis deformans of the hip joint of a fifty-three-year-old man.)

A striking sequel to the vascularization and the ossification of the cartilage is the undermining of the deeper portions of the cartilage. The portions of cartilage thus separated by undermining are often found to lie deep within the spongiosa and in this position mark the site of the original boundary between cartilage and bone (Figs. 3 and 4).

As previously mentioned, the periosteum in general does not take any part in the formation of the marginal exostoses. However, in the more advanced cases of arthritis deformans, periosteal bone proliferations covered by newly formed cartilage can be seen at the insertion of the tendons. The synovial membrane may also be the site of proliferative changes.

Despite the changes in the surface of the cartilage, vascularization and ossification of the basal cartilage layer rarely take place. The cause for this is either that the calcification zone of the joint cartilage is very broad, or the subchondral bone is very compact. The subchondral bone is thus protected against functional and mechanical damage in spite of the loss of elasticity in the overlying cartilage (Pommer). Hence, it is obvious that arthritis deformans is dependent for its development upon the combination of functional and anatomical circumstances.

The layer of cartilage covering large marginal exostoses may be worn away and the underlying bone be exposed and made smooth, giving rise to a hard, highly polished surface (Fig. 5). Frequently in various areas of the polished surfaces small portions of the *marrow have become* exposed by mechanical irritation and wear. When the degree of irritation and trauma resulting from the impaired mechanical function of the part is considered, it is easily understood why increased bone resorption is found side by side with increased new bone formation. In this union of opposite phenomena is found the explanation of the characteristic deformities of the joints in arthritis deformans.

In the *more advanced cases of this disease, one can find,* especially in the subchondral bone and along the junction between cartilage and bone, callus and resorptive tissue proliferations. This callus formation arises as a result of the splitting and cracking of the bone and of the cartilage. These reactive processes make clear the striking picture of porosity and condensation that is so obvious in the macerated specimen.

Microscopic cysts are likewise found in the exposed subchondral marrow spaces (Fig. 5). These cysts are either the result of encapsulation of hemorrhages or of areas of detritus. Thus is disproved the theory of Kimura and Ziegler that the cause of arthritis deformans lies in regressive changes in the subchondral bone (Pommer). In far advanced arthritis deformans, the *so called cartilage nodules are observed;* these are situated in the marrow spaces of the spongy bone beneath the polished joint surface. According to Pommer and Lang (1924), the cartilage nodules can originate in two ways: first, as callus resulting from microscopic fractures, and, second, as fragments of joint cartilage that are broken off and transported as emboli along the capillaries and lymph vessels and grow where they lodge.

With the knowledge of the local origin of the various reactive and progressive changes in arthritis deformans, it can be understood how atrophy, caused by age and inactivity, occurs at the same time that these other changes are taking place. Thus, not only sclerotic but also atrophic polished areas are observed.

Considering the above described findings and their explanations, the distinction between the atrophic and the hypertrophic or between the degenerative and the hyperplastic types of *arthritis deformans* is not necessary.

According to Pommer and Beitzke, the varieties of arthritis deformans present no distinctive differences; they are but gradations of a process that is uniform as regards its origin. Naturally, in the explanation of these differences, individual variations must be considered. These variations have their origin in the anatomical structure, in the functional requirements, and in the *effacement* of the part by use (Lang, 1924).

A distinction between the chondral and osseous forms of arthritis deformans is also unnecessary. For, in the final analysis, it is the damage

FIG. 5

Polished articular bone surface with cyst formation in the underlying spongiosa. (Arthritis deformans of the hip joint of a fifty-three-year-old man.)

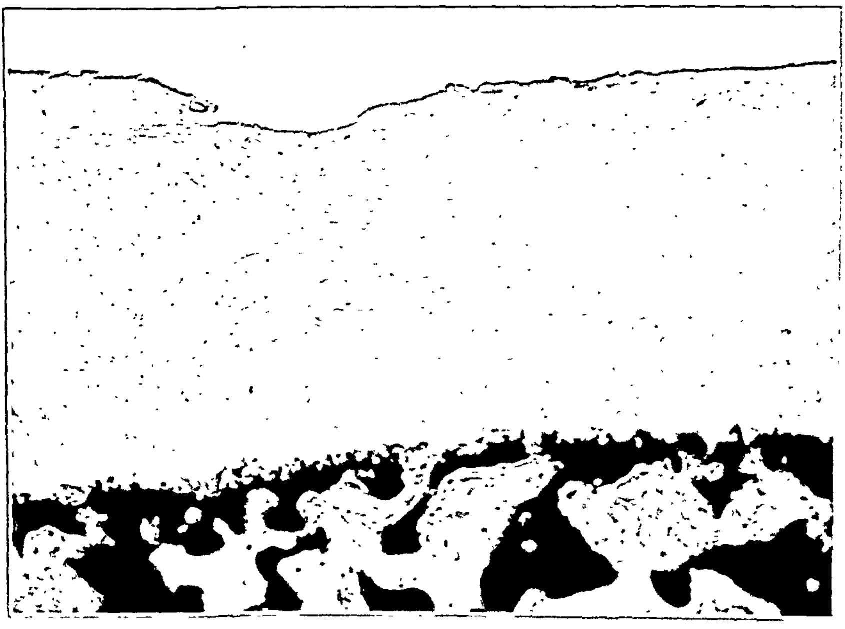

FIG. 6

Head of the femur of a nine-year-old girl with arthritis deformans juvenilis. Note the loss of substance in the articular surface of the cartilage.

FIG. 7
Arthritis deformans juvenilis (Legg's disease) in a nine-year-old girl with formation of marginal exostoses and mushrooming of the femoral head.

to the cartilage with its resultant loss of elasticity that is responsible for the origin of the disease (Lang, 1931).

In spite of the numerous anatomical and pathological investigations as to the nature of its origin, arthritis deformans has more recently been called, from the clinical and roentgenological points of view, an "arthrosis". The designation of arthritis deformans as "arthrosis" is to be avoided, as the termination "osis" is used in pathology to indicate changes of a degenerative nature. Thus, for example, nephrosis indicates any degenerative change in the kidney, and nephritis, an inflammatory process. It is asserted that constitutional influences have to be considered in the development of arthritis deformans, and, therefore, the designation "arthrosis" is preferable to "arthritis". This argument, however, is not sound. These considerations are important for every inflammatory process, regardless of what organ or structure is the site of the inflammation. Constitutional influences can, nevertheless, affect the type, the intensity, the extension, and the outcome of an inflammatory process (Lang, 1931). It is absolutely necessary to keep in mind the histological distinction between inflammatory and degenerative processes. This distinction is not superfluous and is of value since inflammatory and degenerative processes frequently occur side by side (Lang, 1931). Under all conditions, *the character of arthritis deformans is a chronic, proliferative, non-infectious inflammation of the joint* and, therefore, the only justifiable designation of this process is "arthritis".

Regarding the *causes of arthritis deformans*, it must first of all be admitted that a direct relationship can exist between arthritic changes and certain systemic diseases. But vascular changes, especially arteriosclerosis, are not the main cause of arthritis deformans. The vessel changes that are sometimes seen are generally either independent of or secondary to the inflammation or localized circulatory disturbances, such as occur in the advanced cases of arthritis deformans. Likewise, there is no proof that under natural and non-experimental conditions the cause of primary arthritis deformans is due to necrotic changes of the cartilage. Furthermore, there is no confirmation of the view that regressive and atrophic changes of the subchondral bone are of importance in the development of this disease.

The only satisfactory explanation for arthritis deformans is found in the functional theory of Pommer. This theory presupposes that the joint cartilage, through its elasticity, protects the subchondral bone and its marrow from the irregular, localized effects of impacts, jarrings, and pressures arising from normal function. Following damage to the joint cartilage, with subsequent loss of its elasticity, the mechanical effects of normal joint function become more or less localized and are transmitted unmodified to the joint structure resulting in a reactive vascularization and ossification of the cartilage.

The damage to the joint cartilage arises: first, from unequally distributed or violent strains,—for example, of heavy labor, of bent posture, or of those occurring in tabes dorsalis in which the pain sensibility is lost; second, through diseases of the joint cartilage itself; third, through diseases of the joint capsule, the synovial membrane, and the subchondral bone; and, fourth, through endogenous metabolic and endocrine influences (Lang, 1931).

The recognition of the functional and mechanical importance of the joint cartilage as the protective covering of the subchondral bone (Roux) demands that the mechanical and functional damages to the joint cartilage be adjudged the most important factor, not only for the pathogenesis, but also as the etiological factor of arthritis deformans. An especial confirmation for the functional theory of arthritis deformans is the fact that this disease is frequently found in certain occupations. Sufficient proof for this statement is given in the literature.

R. Beneke has pointed out the possible sequelae of old traumatic changes. I was able to confirm his idea by my studies of juvenile joints, in which I found evidences of the end results of more or less extensive traumatic changes (Lang, 1922, 1924). By these studies, this theory is substantiated: that arthritis deformans is already initiated in the early years of life and, therefore, the disease has to be considered as a consequence of trauma carried over from childhood and adolescence. When the after effects of trauma in early life are considered, it becomes evident that in the sequelae of chronic, oft-repeated functional traumata lies the etiology of arthritis deformans of the adult (Lang, 1931).

FIG. 8
Fissure formation in the cartilage of the epiphyseal line. (Legg's disease, nine-year-old girl.)

I was able to investigate the juvenile form of arthritis deformans in Perthes-Legg-Calvé's disease of the hip joint, Köhler's disease of the first and second metatarsal bones, and other so called "aseptic necroses" (Lang, 1922, 1924, 1931). In these diseases the characteristic diagnostic features of arthritis deformans were present,—namely: changes of the joint cartilage, vascularization and ossification of the cartilage, and marginal exostoses (Figs. 6 and 7).

In the juvenile type of arthritis deformans the epiphyseal zone presents changes typical of those found in arthritis deformans of adults. As a sequel to these changes, cessation of ossification occurs in the involved portion of the epiphyseal line. In the cases of juvenile arthritis deformans are found striking examples of fissure formations, splintering and fragmentation of cartilage, of subchondral bone, and of the bone and cartilage along the epiphyseal line (Fig. 8). These changes stimulate callus formation with the production of new cartilage and bone so characteristic of juvenile arthritis deformans. The splintering and fissurations are found along the bone cartilage juncture; their lines of direction are in part parallel with and in part at right angles to the lines of strains (Fig. 8).

The behavior of the epiphyseal zone and the size, position, and structure of the epiphyseal bone determine whether adjustment and distribution of the vibrations of impacts and jarrings are possible or whether

FIG. 9

Section from the head of the femur in Legg's disease with malformation of ossification.

FIG. 10

Synchondrosis of the acetabular cavity of a twelve-year-old girl with extensive traumatic changes along the epiphyseal line and callus formation.

splintering and fragmentation with displacement of the fragments will occur (Lang, 1931). More or less extensive hemorrhage with subsequent hemosiderin deposits and blood-cyst formation complete the picture of previous trauma.

From my studies it is evident that functional traumata are determining factors for the origin of juvenile arthritis deformans. The continuous effects of this trauma are responsible for the insidious character of juvenile arthritis deformans.

The following two cases of Perthes' disease are illustrative of this point.

The first patient was a normal twenty-two-year-old male who fell from a ladder, injuring his right thigh. X-ray examination showed an oblique, incomplete, subtrochanteric fracture. After six weeks in a plaster cast the patient was discharged with the x-ray examination at this time showing complete healing of the fracture. Two years later a pronounced flattening of the femur head was roentgenologically visible which, three and a half years after the injury, was far advanced. At this time, because of pain and limitation of motion, the joint was opened and a mushroom-shaped femoral head removed. This case is clarified only by postulating damages to the joint cartilage and—what is especially important fissure formations in the subchondral bone with a consequent disturbance of the structural equilibrium, damages which were, of course, invisible in the first two x-ray films.

After six weeks of rest these areas were subjected to continued functional traumata with a resulting disturbance of the processes of reconstruction. The final microscopic picture shows tiny pseudarthroses lined by new cartilage, areas of osteitis fibrosa with islands of splintered and pulverized bone, cysts containing hemorrhages and débris, and all the characteristic signs of arthritis deformans.

The second patient was a fifteen-year-old boy who developed Perthes' disease following a gunshot wound of the soft parts about his right hip. Neither bone nor joint structures were involved. X-rays were taken immediately and at periods of nine and eleven months after the injury (Just). The first roentgenological examination failed to show any damage to bone or joint. In the examination made nine months after injury there existed well advanced changes in the femoral head characteristic of Legg-Perthes' disease. These changes were more marked in the last x-ray. Here, as a result of a relatively mild localized indirect trauma (as compared with the first case cited), there developed a characteristic deformation of the femoral head.

These two cases are representative of latent bone changes resulting from: first, severe direct trauma and, second, from relatively mild indirect trauma.

The bilateral, symmetrical type of Legg's disease of the hip joint is exceptional. When the disease is bilateral it is usually found that there existed a developmental malformation of both femoral epiphyses. It is well recognized that a developmental malformation of an epiphysis predisposes that structure to damage by relatively mild functional and actual traumata (Fig. 9).

The importance of trauma for the origin of juvenile arthritis deformans is in no wise lessened because no history of injuries can be elicited. In comparative studies, I was able to demonstrate histologically, in many cases giving a negative history for trauma, more or less severe traumatic changes with their sequelae (Lang, 1924) (Fig. 10).

When there is a history of trauma without subjective or objective symptoms being present immediately after the injury, one must consider the sequelae that may be found at a later date. An example of this is the post-traumatic atrophy of the vertebrae described by Kümmell. This atrophy may lead to almost complete disappearance and collapse of the body of a vertebra but it does not become evident until some time after the original injury.

In estimating the importance of trauma, there can be no doubt that mechanical damage to a joint, due to excessive athletic activity in early life, will lead to arthritis deformans (Lang, 1931).

In conclusion, it is evident that there are no fundamental differences between arthritis deformans of the adult and juvenile arthritis deformans. Both types of the disease originate after damage to the articular and joint cartilage with subsequent loss of its elasticity. This loss of elasticity removes the protection that the normal cartilage affords to the subchondral bone against functional and mechanical influences.

As a causative agent for arthritis deformans in adults, the damage to the cartilage, resulting from excessive strains, is of primary importance. In juvenile arthritis deformans, direct and indirect traumatic damages to the cartilage and, especially, to the osteochondral junction are held responsible. The decisive factor for the progressive course of both types of arthritis deformans is the action of the functional requirements which, acting as a source of constant irritation, forms *the basis for the progressive character of the disease.*

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OPERATIVE TREATMENT OF CHRONIC DISLOCATION OF THE PERONEAL TENDONS

BY ELLIS JONES, M.D., LOS ANGELES, CALIFORNIA

Traumatic dislocation of the peroneal tendons is relatively rare, but displacement of one or both of the tendons, when it does occur, causes serious disability. While permanent displacement of these tendons anterior to the malleolus not uncommonly follows as the result of paralytic deformity, it gives rise to no symptoms and requires no treatment other than the correction of the talipes calcaneus, which usually accompanies it.

Traumatic or habitual displacement of one or both of the tendons demands operative interference, since the superior retinaculum is invariably ruptured, and with rupture of the retinaculum there remains no structure capable of retaining the tendons in their normal position. Edwards [1] and others have shown that the peroneal groove on the posterior surface of the lateral malleolus when present is usually very shallow and that the lateral ridge when present, and even when augmented by cartilage, is not of sufficient proportions to retain the tendons in the groove. Edwards has found that seven per cent. of the fibulae examined were actually convex transversely in this region, and it would seem that this type would be especially prone to dislocation of the tendons.

Various types of operations are described in the literature. In chronic cases, Whitman [2] advises suturing the displaced sheath in its normal position, or deepening the peroneal groove, or, if the displacement appears to be due to a shortening of the tendon, he suggests that the tendon be divided and lengthened in the usual manner. Retention of the displaced tendons by the formation of osteoperiosteal flaps, fashioned from the external malleolus, looped around the tendon, and resutured to the malleolus posteriorly, is the method which has been used successfully by Kraske [3] and Kramer [4] in an effort to reconstruct a retinaculum of sufficient strength to insure retention. An artificial retinaculum has been similarly reconstructed by Kraske from osteoperiosteal tissue freed from the calcaneum and external malleolus. Albert [5] and Lannelongue [6] believe that the luxation is due to an abnormal flattening of the malleolus. Albert deepened the groove. Lannelongue sought to heighten the eminence surrounding the groove by means of a periosteal bone flap from the malleolus. In Lannelongue's case a well-developed crista formed, easily palpable on the malleolus, and a good functional end result was obtained. König [7] reported a favorable result from the use of a periosteal bone flap used as a retention loop around the tendons. More recently Kelly [8] reported two successful end results following the use of a bone graft, employed to form a new and capable external lip to the peroneal groove, which effectively prevented the tendons from slipping forward. Lexer [9] utilized the palmaris longus, inserting this tendon into the external mal-

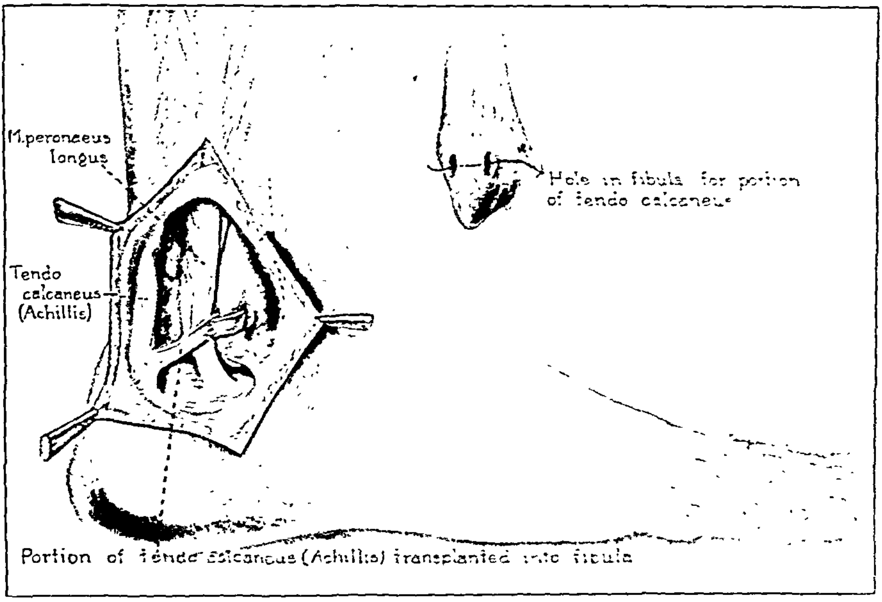

FIG. 1

leolus in the form of a loop encircling the peroneal tendons and maintaining reduction. Estor[10] recommended the reconstruction of a capable retromalleolar groove and the temporary use of a silver wire to maintain reduction. Hanson[11] employed a periosteoplasty, loosening a flap of periosteum from the fibula and a similar flap from the calcaneum, suturing both flaps together over the peroneal tendons.

The writer presents the following method of tenoplasty, by which reduction of the dislocated tendons is maintained by a tendon slip fashioned from the tendo achillis at its calcaneal insertion and implanted into the external malleolus, the transplanted tendon acting as a thoroughly adequate substitute for the ruptured retinaculum.

OPERATION

The peroneus longus tendons are exposed by a straight incision, two inches in length, extending downward directly behind the external malleolus. The tendo achillis is exposed and a tendon slip, two and one-half inches in length and approximately one-fourth inch in width, is freed from above downward and left attached at its calcaneal insertion. The peroneal tendons in their sheath are firmly retracted. A hole is drilled transversely through the fibula one inch above the tip of the malleolus, and the tendon slip is passed from behind forward through the drill hole, looped posteriorly, and sutured with twenty-day chromic suture both to the periosteum of the fibula and to the tendon slip itself, while the foot is held strongly dorsiflexed in full supination. The peroneal sheath is not opened. The skin is closed, and the wound is dressed in the usual manner. A short plaster cast is applied with the foot in moderate supination

and ninety degrees of flexion. The plaster cast is changed at the end of two weeks, a short cast being reapplied with a walking stirrup incorporated to permit guarded weight-bearing. All fixation is removed at the end of six weeks, at which time the patient is permitted full activity.

CASE REPORT

C. L., aged twenty-two years, student, was examined on December 18, 1931, because of persistent pain and disability in the right foot and ankle joint. The patient gave a history of a football injury three years previously, at which time he felt the tendon on the outer side of his foot slip over the bone. He was able to push the tendon back and obtained temporary relief from ankle strapping and support, but was acutely disabled for one month. He was unable to continue at football. He attempted collegiate football this year, wearing a tight bandage, but complained that he was immediately disabled whenever the tendon slipped forward and that the tendency to slipping under slight effort was increasing. He stated, "I never know when it is going to slip and throw me". The patient was submitted to operation as above described on December 19, 1931. At operation the sheath was found intact. The superior retinaculum was entirely absent. No gross deformity of the fibula was evident. All fixation was removed on January 28, 1932, and the patient was permitted full activity. Examination on February 10, 1932, showed a normal range of motion with excellent stability of the ankle joint. On March 15, 1932, the patient stated that he had reported for spring football and was engaging in full activity and that the ankle was symptomless.

CONCLUSION

The operation here described prevents redislocation of the peroneal tendons by furnishing a capable substitute for a retinaculum and fulfills all the physiological, anatomical, and mechanical requirements.

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ECHINOCOCCUS DISEASE OF BONE

Report of Two Cases Involving the Pelvic Girdle*

BY BRADLEY L. COLEY, M.D., NEW YORK, N. Y.

Hydatid disease of the skeletal system is an extremely rare bone lesion. Dew[1] and Hsieh[2] have found that it is present in less than one per cent. of all cases. Its frequency has been given by other observers as follows: Thomas[3], one and six-tenths per cent.; Vinas[4], one and twenty-nine hundredths per cent.; Mills[5], one per cent.; Dévé[6], nine-tenths per cent.; Vegas and Cranwell[7], fifty-nine hundredths per cent. The rarity of reports of bone hydatid occurring in the American literature justifies recording two cases which were seen and studied at Memorial Hospital.

Case 1. R. R., aged twenty-six, was born in Southern Italy in 1905 and migrated to the United States in 1921. Since then he has lived in Newark, New Jersey. His grandfather, both parents, wife, two children, five sisters and brothers are apparently free from disease. He is a tailor and there has been no association with dogs or other animals. He was in excellent health up to Christmas, 1928, when he complained of a pain in the right knee, to which little notice was paid until April, 1929, when he was admitted to St. Michael's Hospital, Newark, complaining of severe pain in the right knee and limitation of motion in the right hip joint. Examination at that time showed a well developed and nourished young Italian in good physical condition, not acutely ill, with an intra-abdominal mass the size of an egg in the hollow of the right ilium and, attached to it, a small mass deep in Scarpa's triangle on the right side. There was limitation of motion in the right hip joint in all directions. Biopsy from the crest of the ilium failed to show pathology. Because the tumor clinically resembled osteogenic sarcoma, the patient received seven injections of Coley's toxins and was then referred to Memorial Hospital, where, in September, 1929, he was admitted to the Bone Tumor Department.

Physical examination on admission was essentially as noted above. There was no gross deformity of the right ilium; Wassermann, urine, and blood studies were all normal; eosinophils were one per cent. X-ray report on September 30 showed: "A process of extensive irregular decalcification with areas of increased density throughout the ilium; no gross bone destruction or production; films of lungs negative for metastases or tuberculosis".

No x-ray diagnosis was ventured. Clinically it was considered to be an osteogenic sarcoma and the patient received eighteen injections of Coley's toxins and 177,000 hours of radium pack at a distance of ten centimeters, over a period of eight months. Little change was noted in the physical condition of the patient, though the series of films showed progressive decalcification in very irregular fashion. Biopsy by aspiration was attempted on May 14, 1930, but the aspiration failed to establish the diagnosis.

On July 17, 1939, there appeared several ounces of yellow, necrotic material from the mass in the right groin, issuing from a sinus at the site of the previous aspiration. Microscopic examination showed this material was pus and the sinus failed to heal. Operation for further drainage on September 6, 1930, produced material, which was regarded by the pathologist, Dr. Stewart, as suspicious of echinococcus disease.

On October 30, 1930, an abscess which had been slowly developing over the right sacro-iliac region was incised and at this time a number of typical daughter cysts were obtained and a definite diagnosis made. The ilium was found to be a hollow shell, with

* From the Bone Tumor Department, Memorial Hospital, New York.

many small fragments of bone loosely held together. A number of these were free sequestra and were lifted out of the wound.

Patient is at present free of other demonstrable evidence of echinococcus disease; there is no fever, jaundice, or enlarged liver. White blood count is 9,300; red blood count 4,500,000; hemoglobin eighty-five per cent. There has been severe pain in the right hip joint and leg, but at present the patient is in fair condition. However, the latest films of the right ilium show almost total destruction of this bone, and involvement of the fifth lumbar vertebra, and telescoping of the right femoral head into the hollow of the sacrum. There is no swelling or tumor of the soft parts. Although the entire right lower extremity is functionally useless, the patient has been able to get about fairly well on crutches. There has been a marked rotation of the pelvis on the unaffected side.

CASE 2. A male, aged fifty-eight, by occupation a carpenter, who was born in Russia and had lived there for about twenty-five years, was admitted to the Memorial Hospital,

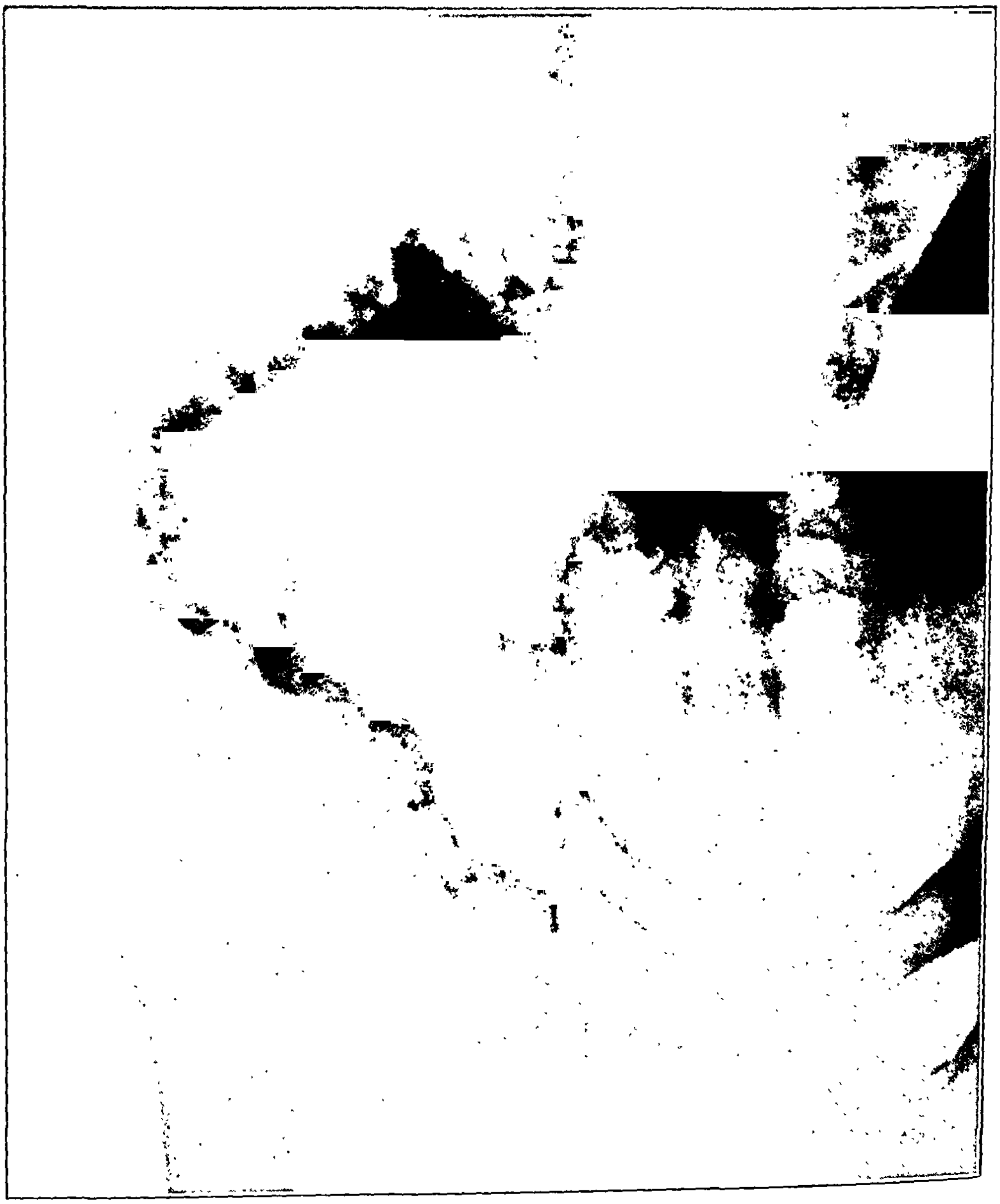

FIG. 1

Case 1. Roentgenographic appearance of right ilium, February 5, 1930, showing extensive involvement which includes the right wing of the sacrum.

October 1, 1926, with a history which had begun five years ago when the patient fell, striking his sacrococcygeal region. Immediately thereafter he experienced severe pain in the back, radiating down the lower extremities to the knees. Walking was difficult. Although these symptoms had persisted more or less constantly since onset, there had been an increase in their severity during the few months prior to admission. He was referred to the Memorial Hospital from the Neurological Service at Bellevue Hospital, where he was found to have extramedullary involvement of the sacral roots; and where roentgenograms of the sacrum were said to show productive osteo-arthritic changes of the lumbar spine, and a polycystic degenerative process involving the left ala of the sacrum, and characteristic of giant-cell sarcoma.

The patient was under the care of Dr. William S. Stone, then Clinical Director of Memorial Hospital, with whose permission this case report is included.

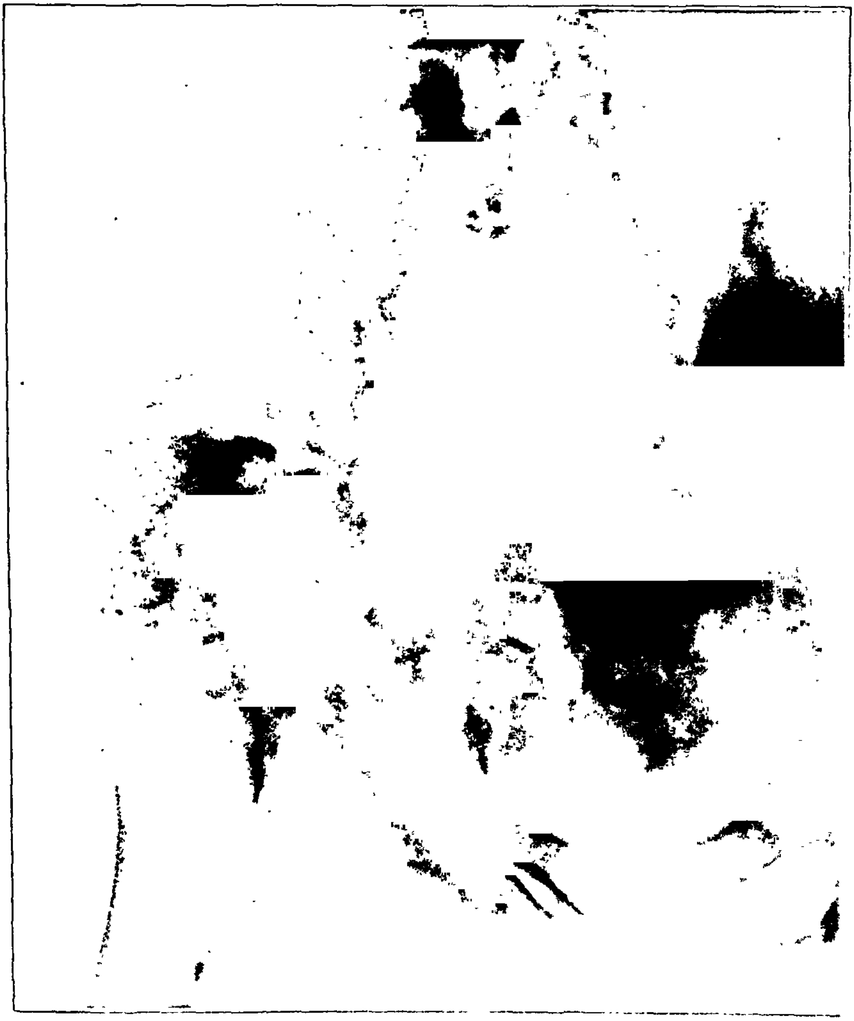

Fig. 2

Case 1. December 8, 1930. Showing extension of process after [illegible] months' interval as compared with Fig. 1. Note luxation of head due to destruction of acetabulum.

Physical examination on admission: Patient walked with a slightly stooped attitude. There was marked rigidity of the lower spine with little motion in any direction. Rectal examination was negative except for some increased firmness of the prostate. Roentgenograms made October 1, 1926, were reported by Dr. Herendeen as showing destruction of the left wing of the sacrum all the way to the sacro-iliac synchondrosis, with some increased density along the line of the former articulation; pelvic bones showed no atrophy, as in tuberculosis; marked calcification in the arteries of the pelvis and thighs was evident.

One week later patient was shown at the Memorial Hospital conference. No definite diagnosis was made, but high voltage x-ray treatment was ordered immediately. Patient continued to have severe pain, which radiated down the left leg to the foot (nerve pressure?). His general condition remained satisfactory; no palpable tumor could be felt.

On March 4, 1927, further x-rays were made, report of which was: "New formed bone not apparent; probably an osteochondrosarcoma".

On September 15, 1927, more x-rays were taken and the report was: "No extension or change in the tumor".

On December 15, 1927, patient was examined by Dr. Hyslop, attending neurologist, who made the following report:

"This patient I saw at Bellevue over a year ago. At that time he was advised to try radiation. It has not helped. In view of lack of extension of the tumor process and absence of new neurological signs, I think chordotomy is indicated in this case."

The patient disappeared temporarily from observation and the next note, dated March 4, 1929, showed that the patient had been at Mt. Clemens, Michigan, taking baths. No further radiation had been given. Pain had continued, but general condition was well maintained. The area where the radiation had been given over the back of the pelvis was leathery, depressed, and showed beginning telangiectasis. X-ray films made at this time were reported to show some improvement and the patient was shown at conference March 7, 1929, at which time Dr. Stone advised continued observation.

On April 18, 1929, another neurological examination was made by Dr. Hyslop, who stated: "Pain continues; is located in right knee and left foot. Left toes and ankle cannot be extended. Cannot lie down. No urinary disturbances. Constipated. Unable to sleep because of pain. Examination shows knee and ankle jerks absent. Vibration absent in right leg and left ankle. Pin and touch sensation reduced in the fifth lumbar and first sacral segment distribution on the left. There is weakness in flexion of the left foot and ankle. Chordotomy recommended."

At this time the case was referred to Dr. Stone and Dr. Craver and the patient was admitted for chordotomy, which was performed by Dr. Stookey May 1, 1929. Following chordotomy, patient was unable to void and was catheterized every twelve hours. Six days later he became incontinent. Nine days after operation sutures were removed and the wound was healed *per primum*. Patient was dribbling involuntarily. No sensation in the bladder region. Bladder became infected. Permanent catheter inserted with bladder irrigations three times a day. Eighteen days after operation, because of daily elevation of temperature from 103 to 104.6 degrees, patient was seen by Dr. Dean, associate on the Urological Service. Dr. Dean believed the fever was due to obstruction between bladder and kidneys, because relief of the bladder obstruction had not been followed by amelioration of the condition; at cystoscopy he found an inflamed and oedematous bladder, but was unable to pass the catheter more than one and one-half centimeters up either ureteral orifice. Intravenous indigo carmine did not appear from either side in twenty-five minutes.

Patient gradually declined during the following month; was in severe pain with abdomen distended and tender on deep palpation; became irresponsive; took nothing by mouth; drained but slightly from the bladder and, on June 7, 1929, developed oedema of the lungs, Cheyne-Stokes' respiration, and died.

At autopsy the following findings were noted:

1. Echinococcus cyst of ilium, sacrum, and lungs.
2. Acute catarrhal cystitis, ureteritis.
3. Pyelonephritis.
4. Congestion of the liver.
5. Secondary infection with deep abscess, pelvis to thighs.
6. Acute splenic tumor.
7. Small infarcts of spleen.
8. Vegetative endocarditis of aortic valve.
9. Arteriosclerosis.
10. Decubitus chronicus.

Microscopic examination confirmed the gross. The renal lesion showed pyelitis, slight vascular nephritis, marked cloudy swelling, no definite ascending infection. Echinococcus cyst in the lung was old and sterile. The cysts in the bone were active.

INCIDENCE

Hydatid disease, while relatively uncommon in the United States, has received intensive study in countries where it is of frequent occurrence. Among those who have contributed much to our knowledge of this disease may be mentioned Dew[1] of Australia, whose work published in 1928 is one of the most complete sources of information published in recent years. Loucks[8], in 1930, presented a review and reported all cases of echino-

Fig. 3

Case 2. March 21, 1929. Showing roentgenographic appearance of left ilium and sacrum.

coccus disease from Northern China (of which there were only sixteen). One of these cases was made the subject of a further report by Hsieh[8], since it represented the first case of bone involvement recorded in China. The rarity of bone involvement is apparent from the fact that in 1917 Walker and Cummins[9] were able to find only eighty-eight cases in a survey of the literature and, since then, less than thirty scattered cases have been added.

Osseous hydatid, according to Loucks, may in most countries be considered a surgical curiosity. It occurs in about one per cent. of all reported cases. He expresses surprise at the scant attention which this phase of the disease has received in the literature and textbooks, especially when the puzzling and often striking changes, which may be wrought in bone by the parasite, are considered. In North America but three cases of osseous hydatid have been reported,—*i.e.*, Lyon[10] in 1902, Walker and Cummins[9] in 1917, and Hines[11] in 1926. A summary of these cases follows:

Lyon[10], in 1902, presented the third statistical study of hydatid disease in America, the first having been published by Osler[12] in 1882, in which sixty-one cases from the United States and Canada were collected, and the second by Sommer[13], in 1895 and 1896, who assembled 100 cases from the United States. The statistics of Osler[12] and Sommer[13] together include 110 cases. To these, Lyon[10] added 135, thus comprising a total of 241 cases occurring in the United States and Canada up to 1902.

Of these 241 cases, bone involvement was mentioned but once (Case 161). This patient (reported by Woods in 1899)[14] had a small cyst in the head of left humerus in addition to a large cyst of the liver extending through the diaphragm into the right pleural cavity. Daughter cysts, scolices and hooklets were found.

On studying the brief notes on Lyon's collection of cases, however, it would appear that Case 195 might have been an example of echinococcus disease of the left ilium. The note states that the cyst was in the left iliac region, apparently post-peritoneal. In Case 193, the location of the cyst was mentioned as being in the arm above the elbow, but here no mention of bone involvement was made. It must be remembered that this series of collected cases was made prior to the advent of the widespread use of the roentgen ray as an aid in diagnosis.

Walker and Cummins reported a case of a Greek, aged thirty-one, first seen in July, 1915, with symptoms of aching pains in the upper third of the left tibia of three years' duration. The pains were paroxysmal in character and were worse at night. There was no history of trauma and no suspicious contact with dogs. A roentgenogram revealed a cystic condition of the tibia through its upper third. Wassermann test was negative. At operation the tibia was exposed and curetted. Atrophy of the bone and enlargement of the medullary cavity were noted. Many cysts of various sizes were found throughout two-thirds of the length of the bone. No scolices or hooklets were found, but a well defined lami-

Fig. 4

Case 2 Photograph of gross specimen (autopsy) showing echinococcus involvement of sacrum

nation of the cystic areas was observed. Some months later patient again complained of pain in the sinus, which had existed since the first operation. This was again opened, curetted, and packed. Four months thereafter he complained of increased pain and, as the wound was being swabbed out, a collapsed cyst appeared. The curet withdrew another intact cyst. Nine months after the first operation a more radical procedure was undertaken and, at this time, a number of small cysts were found. Sixteen months after the first admission the leg was healed.

Hines, in 1926, reported a case of a white woman of thirty-eight, a native of Ireland, who complained of severe pain in both lower extremities, marked constipation, and polyuria of about ten weeks' duration. There were severe pains in the right leg, followed by numbness and progressive weakness in both legs. Roentgenograms of the spine, spinal fluid examination and echinococcus complement-fixation tests were not made. The patient was acutely ill, with distention of the abdomen, and bilateral flaccid paralysis of the lower extremities; there was loss of thermal, tactile, and pressure sensation of both lower extremities and trunk below the twelfth dorsal segment. Patellar, Achilles, and abdominal reflexes were absent. Two days after admission patient was unable to urinate or defecate voluntarily, became very toxic, and died eleven days after admission. The autopsy findings showed compression myelitis of the lower dorsal and upper lumbar cord; echinococcic pachymeningitis externa of the cord; multiple echinococcus cysts of the eleventh and twelfth dorsal and first lumbar vertebrae; a large, sterile, echinococcus cyst of the right kidney; the bodies of the eleventh and twelfth dorsal and first lumbar vertebrae were so friable that they could be broken easily. This was due to marked sponginess or cystic changes in the bone. Occasional scolices and numerous hooklets were found.

METHOD OF FORMATION OF DAUGHTER CYSTS

According to Loucks[8]:

"Daughter cysts found within the mother cyst, or which have originated by budding into the cavity of the mother cyst, are known as endogenous cysts. This term is used in contradistinction to the type of secondary cyst described as produced by external or exogenous budding. Daughter cysts formed by this method have been supposed to originate from 'foci of granular cells' situated in the cuticle from small islets of germinal epithelium left behind as 'inclusions' in the external laminated membrane or from 'aberrant cell nests' derived from the parenchymatous layer, and by process of exfoliation to escape gradually to the exterior where they continue to develop as separate cysts. This type of growth is comparatively rare, and in man is seen most frequently in cysts of bone, in recurrent cysts found in scar tissue, in cysts of the omentum, and occasionally in cysts of muscle and subcutaneous tissue."

Trauma has been given an important rôle in predisposing to infection, but Loucks and Dew feel that while it may call attention to an already

existing lesion, it has little effect upon the incidence of the disease. Walker and Cummins[9] in analyzing a larger series of bone hydatid cysts have shown that the pelvic girdle is the most frequent site of invasion (fifty-one per cent.). Next in order come the long bones—femur, humerus, tibia, etc.—although cases have been reported involving practically every part of the skeleton. The question as to the probability of direct invasion from the pelvic peritoneum is raised by the frequency of involvement of the bones of the pelvic girdle. However, coexistent visceral and bone involvement is rare. The epiphyseal ends of the long bones seem to afford a site of predilection for the parasite, and it is now generally accepted that it is lodged in the bone by way of the blood stream.

CLINICAL MANIFESTATIONS

This development within bone is essentially slow and free from symptoms, and appears to exhibit its greatest latency in osseous tissue. Pain, a late phenomenon, usually follows some complication,—such as infection or fracture. Loucks wonders that a high percentage of metastatic lesions has not been described for bone hydatid cysts, and in particular for those cases in which there has been a fracture, so that an opportunity has been afforded for the circulation of the viable elements of the organism by way of the ruptured vessels. In this connection, Dew considers Corlette's case[15] was of this type and likens the process to the occurrence of fat embolism following bone injury. Dévé's case[16] developed secondary pulmonary cysts following pathological fracture of the ilium.

DIAGNOSIS

Despite the rarity of this condition in North America, the possibility of its occurrence should be borne in mind as a cause of bone pathology.

Loucks states that in the early stages roentgenograms must be depended upon to suggest the diagnosis, but he admits the difficulties attendant upon correct roentgenographic interpretation, since no one surgeon is apt to see enough cases to draw upon his experience in diagnosis and since very little aid is at hand from other sources. For example, Anderson[17], in an excellent article dealing with the radiological diagnosis of hydatid infections, dismisses the subject of bone lesions in a single sentence.

On the other hand, Dew includes a complete discussion of bone infestations in his monograph on hydatid disease and states that "any bony lesion in an adult which exhibits extremely slow growth, is painless, shows lack of expansion of the cortex and remarkable absence of periosteal reaction in proportion to the degree of destruction present, should be strongly suspected of being caused by the echinococcus parasite".

Leborgne[18] presents an excellent clinical and roentgenographic description of osseous hydatid. From the clinical standpoint he mentions the pains, which are of varying intensity and which at times are entirely absent; and the rounded, indurated swelling, situated in the epiphysis at

the extremity of the bone, unassociated with increased surface temperature, requiring many months, even years, for development and sometimes ending in spontaneous fracture. Quoting Leborgne:

"Roentgenographic examination in the early period of the disease reveals one or many small cystic areas, like bunches of grapes, rounded, punched out, sharply outlined, but without the reaction of condensing osteitis at the periphery, that is to say, without new bone formation. At a later period when the bony enlargement is perceptible on palpation, alteration in the contour of the bone is observed. This is in the nature of a fusiform expansion without new bone formation of any sort. The bone is seen to be reduced to a shell under the periosteum which may be broken through spontaneously. The bony swelling has a typical, areolar appearance, infiltrated by large cavities of more or less irregular contour, but discrete. From the anatomical point of view it corresponds to the process known as cystic osteitis.

"The absence of bone hyperplasia enables us to classify the x-ray appearance among the rarifying osteopathies and to rule out completely osteomyelitis, even of the attentuated form, which is sometimes associated with cystic cavities (Brodie's abscess). Bone syphilis or gummatous conditions, which produce cavities of rarifying osteitis, are encircled by a limiting ring of new bone formation.

"Among the rarifying osteopathies from which osseous hydatid must be differentiated are certain central osteosarcomata, round-cell or spindle-cell; but they must be distinguished by the different clinical setting, in the absence of sharp outline which permits us to separate hydatid disease of the bone.

"Among the other bone diseases which closely resemble hydatid disease of bone Recklinghausen's disease must be considered. The chief radiological difference lies in the contour of the rarifying areas, which are more clearly cut in hydatid disease. Although in Recklinghausen's disease the cavities correspond to pseudocystic nodules without true walls, or a process of osteoclasis infiltrates the periphery as in a malignant tumor, in hydatid infiltration of bone a true cyst with clear-cut walls is seen. In these cases clinical and general examination of the skeleton will be of great assistance in arriving at a diagnosis, since Recklinghausen's disease involves many bones. On the other hand, in solitary bone cysts the difficulties in diagnosis are much greater, because of the similar x-ray picture and the fact that there is but a single lesion. In such an instance the Casoni test will be helpful."

Leborgne concludes his description with a report of a case of a girl of nine, in which the humerus was involved.

It should again be noted that in the two Memorial Hospital cases herein reported the diagnosis was not made from clinical or x-ray study. It remained for the pathologist to determine the true nature of the condition, in the first case as a result of operative material submitted and, in the second, at autopsy.

Once a diagnosis has been suspected or even suggested, complement-fixation reaction or a Casoni intradermal test may be of value. Loucks states that in general the Casoni test is of most value in the diagnosis of early and uncomplicated cysts; it is of little significance in old, complicated cases. For a further discussion of the various tests for echinococcus disease, the reader is referred to Loucks' monograph.

HYDATID DISEASE OF THE INNOMINATE BONE

While the disease may occur in any of the flat bones, Dew[1] states that it is seen in its most usual and typical form in the innominate bones. Buzzi[19], Corlette[15], Syme[20], Landivar[21], Rendle[22], Bell[23], and others have reported cases. According to Dew, the latency of hydatid disease of the ilium is remarkable, the patient usually presenting a large swelling due to extension into the soft tissues from this comparatively thin bone. The thickness and tension of the gluteal muscles tends to cause this extension to develop in the iliac fossa, the pelvis, or the outer part of the thigh and a gradually increasing painless swelling develops in one of these areas. The swelling is fluctuant, indurated, relatively fixed, and is not tender to palpation. It is readily confused with other swellings in this region. Among these may be mentioned cold abscess, sarcoma, or chondroma with cystic degeneration.

EXPERIMENTAL PRODUCTION OF HYDATID DISEASE OF THE BONE

Dévé and Rolland[24] performed some interesting experiments in dealing with the production of bone echinococcus disease in a rabbit. Material was inoculated into the interior of the diaphysis of the tibia through a trephine opening about two centimeters from the joint. The animal died two years and three months later. Roentgenogram of the tibia, which had been inoculated, revealed the presence of multiple small cystic areas, rounded, confluent, and appearing to extend into the interior of the diaphysis up to five centimeters from the point of inoculation. Microscopic sections of the bone made throughout its entire length revealed that the parasitic invasion had extended down to the lower epiphysis. In two years the parasite had traversed the bone for a distance of more than ten centimeters. The daughter cysts were fertile and bore numerous capsules enclosing adult scolices. The bone cortex in the neighborhood of the parasitic infection did not present any thickening of a reactionary nature or any lesion of hypertrophic osteitis.

Dévé and Rolland[24] have thus verified in the case of a laboratory animal the various anatomical, pathological, and pathogenic features of uncomplicated osseous hydatid which one of them described[17] a decade previously.

ROENTGENOGRAPHIC FINDINGS

Little of value has been written on the roentgenographic diagnosis of hydatid disease of the bone. Harris[25], in 1919, stated that the disease

is always difficult to diagnose roentgenographically, as the appearance is so similar to that of an osteomyelitis. Others have noted its similarity to fibrocystic disease.

Hsieh[2] gives an excellent description of the roentgenographic features of his case of hydatid disease of the pelvic bone. That it can closely simulate a variety of bone conditions is readily understandable in view of the bizarre roentgenographic changes it may produce. Seldom has the roentgenographic diagnosis been correct: Kienböck and Mayer's recent case[26] is an exception, though lacking pathological or serological confirmation.

It is quite likely that in the future, as more attention is paid to the roentgenographic aspect of bone echinococcus and radiologists become more familiar with its features, the correct diagnosis will more frequently be made.

TREATMENT AND PROGNOSIS

The treatment of osseous hydatid is a discouraging chapter. It has usually consisted of wide excision or incision with curettage and the use of a cauterizing agent, such as carbolic or formalin. This method is condemned by Dew as "always unsatisfactory and, even if carried out thoroughly, when the disease is limited, it is unlikely to succeed".

Dew advocates complete resection of the length of bone involved, followed by immediate reconstruction with an autogenous graft. If there has been widespread destruction of either the soft tissue or bone, or if secondary infection has occurred, amputation is necessary. When the pelvic girdle is extensively involved, as in the cases we have described, treatment is most discouraging. Loucks expresses the view that "the only hope seems to lie in the discovery of some anthelmintic drug which, when administered by the intravenous route, will have a specific lethal effect upon the echinococcus organism".

Because of the fact that the organism develops in such a slow and symptomless manner, a pathological fracture is frequently the first manifestation that calls the patient's attention to the lesion. Pain is a late phenomenon and is generally attendant upon some complication, such as infection, pathological fracture, or perforation of the cortex. The delay in the recognition of the disease is one of the chief reasons why the prognosis is ultimately so discouraging. Dévé, Billiard, and Decoularé-Delafontaine[27], after experiments on infested animals, consider that deep radiation therapy has no effect on the cysts. The ideal therapy—complete extirpation—while adapted to certain visceral cases, affords extreme difficulty in a case of bone cyst. Amputation may give an excellent prognosis in cases where it is rendered necessary because of the extent of bone destruction.

So far as we have been able to determine, the two cases which we have described are the first in this country to have been treated by radiation, although it was given in each case before a correct diagnosis had been

made. In the first case the patient, though still alive, can scarcely be said to have benefited from the irradiation therapy and, in the second case, it is certain that this form of treatment was not followed by any relief.

CONCLUSIONS

1. Skeletal involvement occurs in less than one per cent. of cases of hydatid disease.

2. A roentgenographic diagnosis of osseous hydatid disease is extremely difficult.

3. But three cases of osseous hydatid have been reported in this country up to 1930.

4. Two additional cases (in both of which the bones of the pelvic girdle were involved) are reported from the Bone Tumor Department of the Memorial Hospital.

5. Intensive radiation therapy failed to check the disease or to alleviate the symptoms in our cases.

6. Hydatid disease should be considered among the causes of unusual bone tumors, from several types of which it is not always easily distinguishable.

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THE TREATMENT OF FRACTURES OF THE SHAFTS OF THE TIBIA AND FIBULA

A New Tibia Traction Apparatus*

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INTRODUCTION

The history of fracture treatment can be traced back through countless generations. Even so, the last half century has witnessed remarkable and dramatic advances in this branch of surgery. In the past, it was regarded as inevitable that the victim of a fracture should carry to the grave some mark of his injury, whether it be a shortened limb, a stiffened joint, a crippling deformity, or a halting gait. Gradually, as methods improved, the seriousness of the residual incapacity diminished: but unfortunately this medieval view has not entirely disappeared, and it is still customary to regard certain permanent disabilities with equanimity. There are surgeons who are content with shortening of a limb provided that the shortening is not more than one inch, who discount angulation of the tibia so long as the angulation is outward and not inward, and who entirely disregard certain degrees of limitation of ankle movement, leaving to the unqualified bone-setter the opportunity of completing their work.

The only standard of treatment, which can be allowed to survive, is that of a limb indistinguishable from normal. Such a result implies not only that the fragments are united in perfect alignment, with no local thickening and with no shortening, but that the bones are fully recalcified, the muscles completely redeveloped, joint movements normal, and the circulation fully reestablished so that there is no recurring oedema. The surgeon cannot shelve his responsibility by invoking the magical powers of a masseuse, but must accept full liability for the disuse changes which he allows to appear. From the first day of treatment, his objective must be a limb so fully recovered that the patient himself remembers only with difficulty which leg was fractured.

If a fracture can be treated either in recumbency or by ambulation, it must be obvious that ambulatory methods will be the more successful. Provided that fixation of the fragments is perfect and no recurrence of deformity is possible, no harm can arise if weight is borne through the limb. On the contrary, weight-bearing will prevent disuse changes from appearing, the indications for massage and physiotherapy will never arise, the incapacity period will be correspondingly reduced, consolidation of the fracture will be secured with much greater certainty, the risk of functional complications will be avoided, and the inconvenience to the patient minimized.

* Based on a paper, film, and demonstration, presented at the Annual Meeting of the British Orthopaedic Association, Newcastle-on-Tyne, October 1931.

FRACTURES WITHOUT OVERRIDING

From the point of view of treatment, fractures of the shafts of the tibia and fibula may be divided into two groups, differentiated by the presence or absence of overriding. Crack fractures, greenstick injuries, and fractures with angulation but no overriding present little or no difficulty in treatment. Perfect reduction can be secured by simple manipulation, and it is easy to maintain reduction by the application of a plaster cast, applied with the limb hanging over the end of a table in the line of gravity. If the plaster is closely fitting and unpadded, weight-bearing may be commenced at once, and the fractures should be firmly united in six to eight weeks.

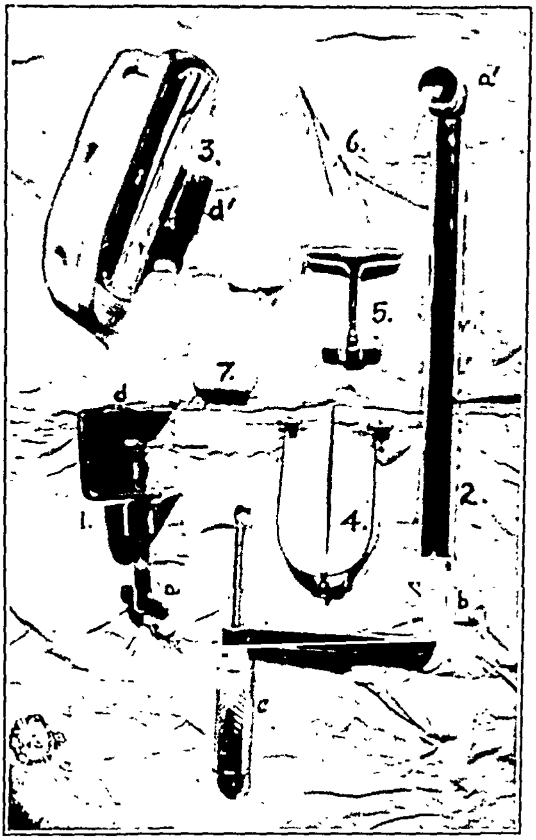

FIG. 1

Tibia Traction Apparatus. *1.* Clamp to fit any table top. *2.* L-shaped traction bar. *3.* Thigh support, padded with sorbo rubber. *4.* Os-calcis stirrup and pin (sterile). *5.* Bristow's pin introducer (sterile). *6.* Sterile forceps for handling pins. *7.* Two sterile gauze pads. After screwing the clamp on the table, the screw handle at *a* swivels into the axis of the screw to allow the top of the traction bar (*a'*) to slide over it and be locked into position. The base of the thigh support (*d'*) fits into a slot on the top of the clamp (*d*). The coarse adjustment of the traction bar is at *b* and the fine adjustment at *c*.

FRACTURES WITH OVERRIDING

It is the second group, including complete fractures with overriding due either to total disengagement of the fragments or to the obliquity of the fracture line, which presents the difficult problem, a problem rendered still more difficult when the fracture is compound and infected, and associated with extensive abrasions and lacerations of the overlying skin.

Disadvantages of Continuous Traction Methods

It has been customary to treat these fractures either by extension apparatus of various types, or by an open operation with internal fixation. Both routines are associated with very real disadvantages and difficulties. Extension methods can only be successfully applied if the services of expert splint-makers and fully trained nurses can be commanded. They demand constant supervision and frequent adjustment, and the advantages of ambulatory treatment are lost. Frequently skin extension is impossible because the skin is so extensively injured. Continuous skeletal traction by means of an os-calcis

pin is not devoid of the risk of infection extending along the pin track, and if strong traction is maintained on the os calcis behind the ankle joint for any length of time, the tendo achillis may become overstretched and an intractable talipes calcaneocavus arise.

Disadvantages of Open Operation

The success of operative reduction is still more dependent on the skill of the surgeon. But, even assuming that asepsis can be relied on with absolute confidence, the stripping up of soft parts from the bone ends causes definite delay in union.

Fig. 2

Showing the limb in traction ready for the application of plaster. The traction apparatus has been assembled and clamped on to the table. The os-calcis pin has been introduced. About two-thirds of the fine adjustment screw has been taken up into the handle.

Difficulties of Treatment by Manipulation and Plaster

It follows that if equally perfect reduction can be secured by manipulation and plaster, this routine is preferable to either extension or operative methods. If it is proposed to attempt this by the ordinary procedure of holding the limb vertically over the end of a table, an assistant must be found, who, with a very insecure grip on the patient's heel can maintain considerable traction for ten or twenty minutes, and at the same time allow neither lateral nor anteroposterior angulation to appear, hold the foot in the same plane of rotation as the patella, dorsiflex the ankle to a right angle, and keep his hands out of the way of the plasterer. Formidable as the task may appear, it is possible in recent injuries, with a well trained assistant. But assistants are not always available; they are subject to fatigue; and fractures are not always seen within a day or two of the injury.

TIBIA TRACTION APPARATUS

For these reasons, a piece of apparatus has been designed which is in fact a mechanical assistant of a very perfect order, indefatigable, and capable of fulfilling all of the demands imposed by a complete fracture of both leg bones. These demands may be enumerated as follows:

1. The knee must be flexed to a right angle.
2. The limb must be held vertically in the line of gravity.
3. Heavy traction must be maintained long enough for the application of plaster.
4. No traction pin should be left in the bone.
5. The foot must be in the same plane of rotation as the patella

6. Lateral and anteroposterior angulation must be fully corrected.
7. The apparatus should be easily portable and applicable anywhere.
8. The apparatus must be adjustable to any size of limb.
9. The operator should be independent of assistants.

The apparatus is simple in construction and design (Fig. 1) and consists of a clamp to fit any table, an L-shaped traction bar with coarse and fine adjustments, and a padded thigh support. It can easily be carried in an attaché case and is roughly the size and weight of a Thomas wrench. Traction is applied to the limb by means of an os-calcis stirrup and pin, but the pin is withdrawn as soon as the plaster is dry so that there is no risk of infection along the track, or of overstretching the Achilles tendon.

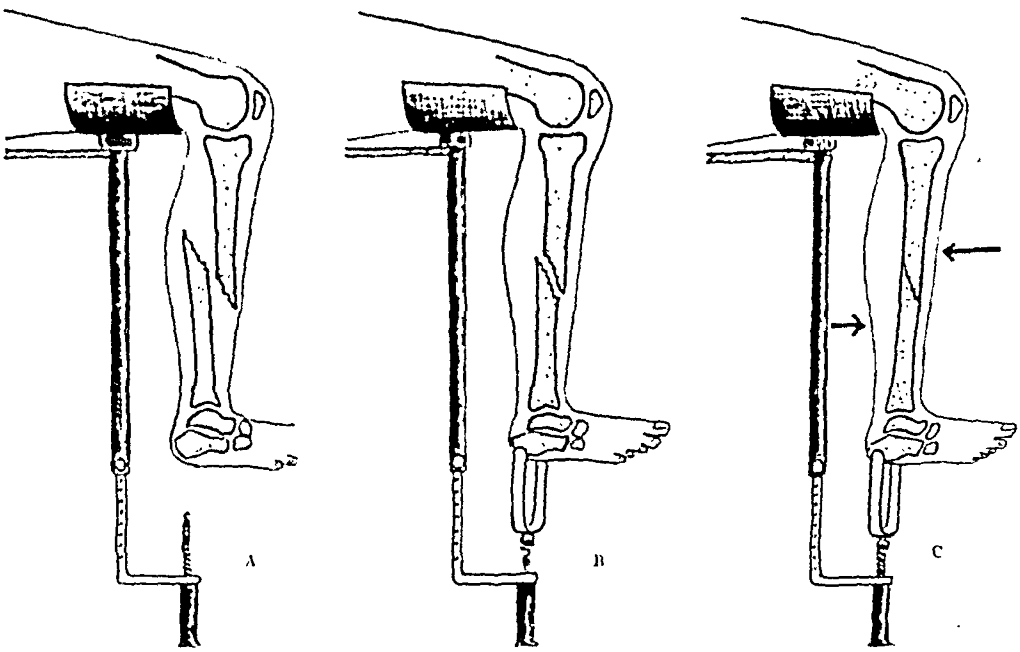

FIG. 3

Anatomical reduction is secured by combining the lateral pressure of the operator's hands with the strong traction of the apparatus.
A. Before reduction.
B. After applying traction.
C. Lateral pressure and traction combined.

APPLICATION OF THE METHOD IN CLOSED FRACTURES

Introduction of Pin

The skin of the foot and leg is thoroughly prepared with ether and iodin. The os-calcis pin is introduced with full aseptic precautions and should be driven through the posterior superior angle of the os calcis, strictly at right angles to the sagittal plane of the limb. Any obliquity in its axis may make it difficult to keep the foot and patella in the same plane of rotation.

Use of Apparatus

The traction bar and thigh support are clamped on to any convenient table; the fractured leg is flexed at the knee joint to a right angle, and

FIG. 4

First stage of the plaster completed. While waiting for the plaster to harden thoroughly, a window is cut over the front of the ankle at the point where recoil of the limb after release of the traction will exert greatest pressure.

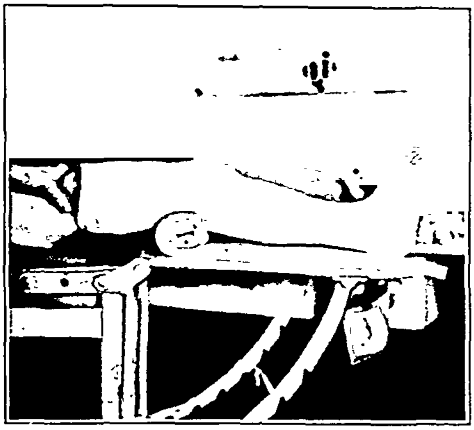

FIG. 5

The complete plaster. The pin has been withdrawn, heel of the plaster repaired, and the plaster extended to the level of the upper thigh.

hangs vertically over the end of the table with the lower thigh resting on the padded support and the heel vertically above the hook of the traction bar. The os-calcis stirrup, fixed in position on the pin, is hooked to the traction bar (Fig. 2). By means of the coarse adjustment the limb is lengthened as much as possible, and the traction bar is fixed at this length. A further three inches of lengthening can be gradually secured by easy rotary movements of the fine adjustment handle. Traction is gradually increased until the limb is quite taut and the operator feels the crepitus of the fragments which are now in apposition. As a rule, full length has been secured by the time that two-thirds of the fine adjustment screw has been taken up. There need be no fear of applying too great an extension; the length of the traction screw has been so adjusted as to make it impossible to do harm by overextension, and slight overlengthening can easily be corrected at a later stage (see *Wedging of Plaster*).

The overriding is now fully corrected, and the traction is such that no angulation can remain; the foot is automatically dorsiflexed to a right angle and if the axis of the pin is correct there can be no rotation displacement. The fragments may now be firmly locked against each other by lateral pressure between the operator's hands. The limb is held so rigidly by the traction that lateral pressure of this type cannot produce angulation, but can only impact the fragments in such a way that anatomical reduction is secured. This lateral pressure should be constantly maintained by the operator until the plaster is dry. *The apparatus itself will maintain full length and correct alignment, and the lateral pressure of the operator's hands will secure perfect apposition* (Fig. 3).

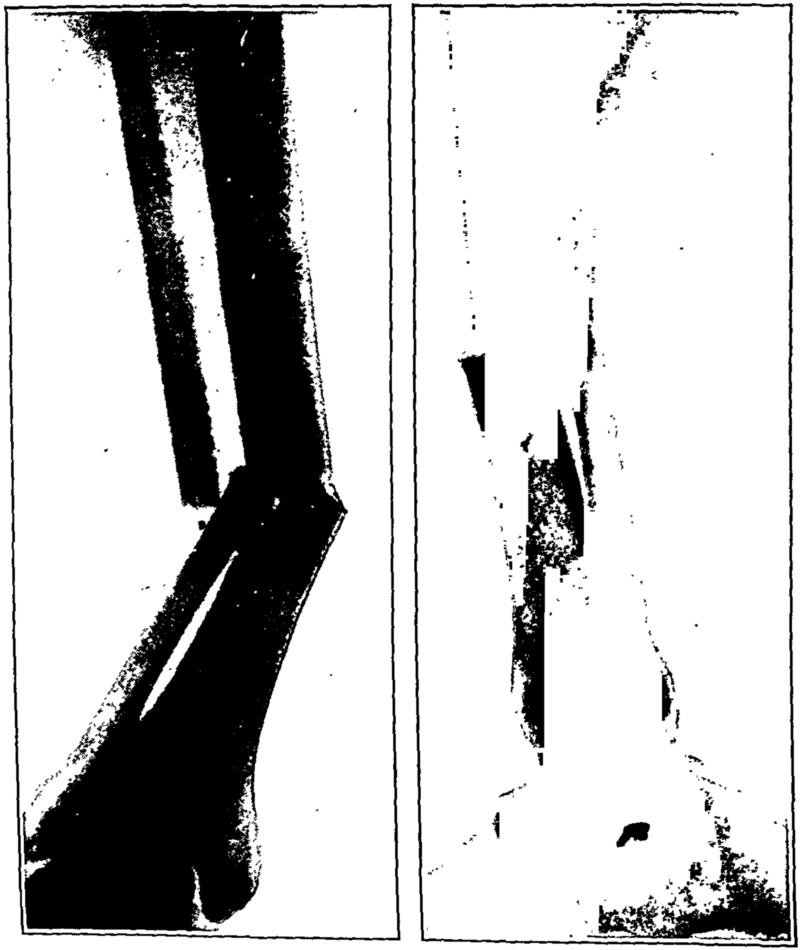

FIG. 6-A

Complete fracture of the shafts of both leg bones. (This fracture could easily have been reduced perfectly without the traction apparatus, but it was the only case available when the film was being prepared. It is reproduced here because it illustrates a complication.)

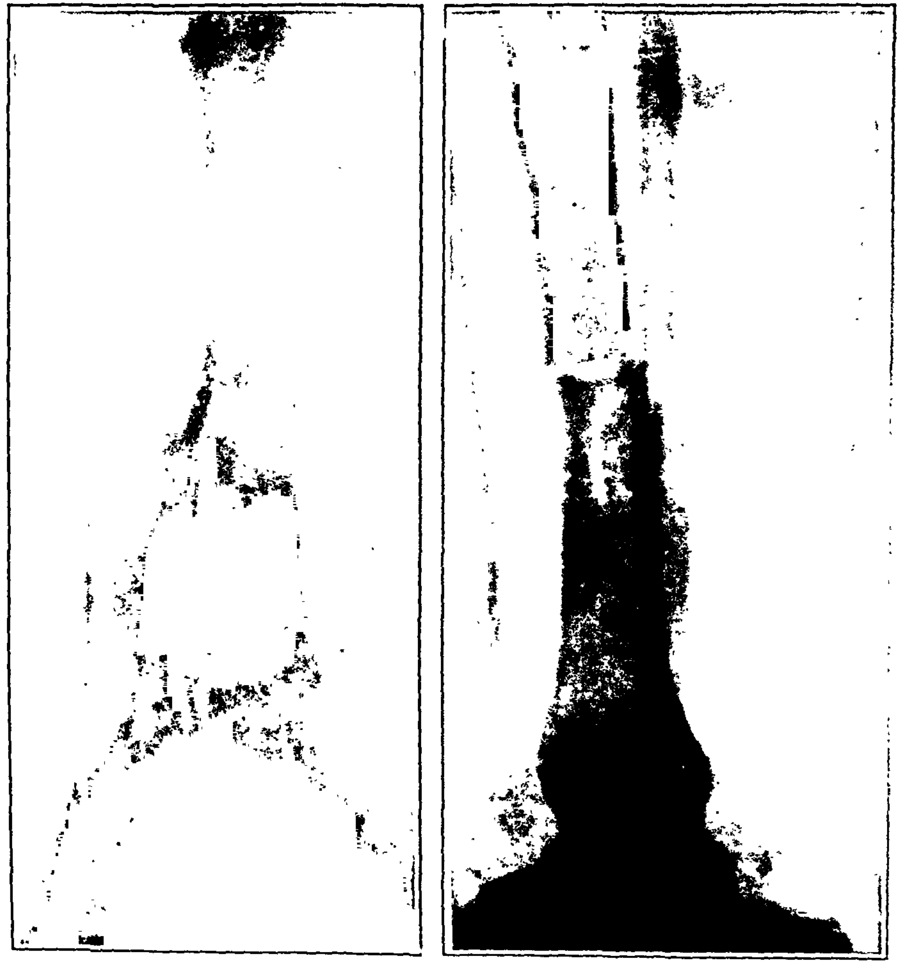

FIG. 6-B

After reduction (through plaster). The limb has been overlengthened and the plaster fits so closely that the separation of the fragments will be maintained unless the traction is released by a circumferential cut in the plaster (see text).

Application of Plaster

An unpadded plaster cast is applied from the toes to the level of the knee joint. A plaster slab, prepared quickly so that it is still quite moist and soft, is guided through the stirrup, placed in direct contact with the skin of the back of the leg and sole of the foot, and molded to the limb by means of a thin cotton bandage lightly applied. The cast is now completed in the ordinary way with circular turns of plaster bandage.

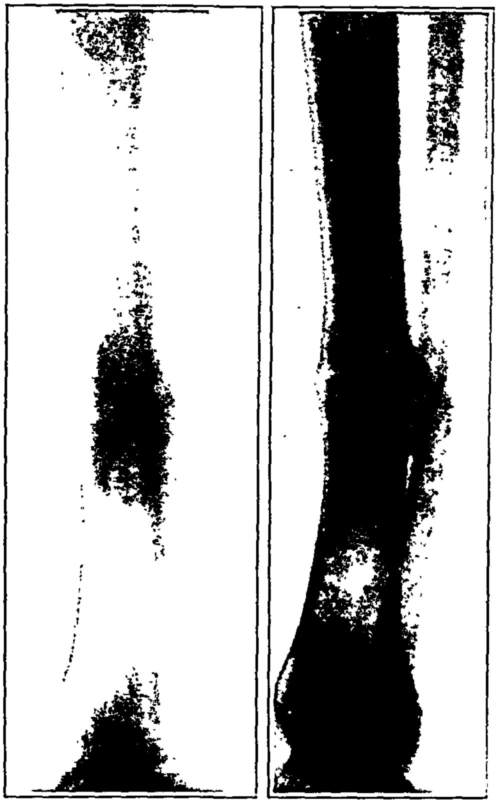

FIG. 6-C

The end result. The overlengthening has been corrected and union has resulted.

Window in Front of Ankle

The traction must be maintained until the plaster is quite hard. While waiting for it to dry, it is a wise precaution to cut a small vertical window one inch wide over the front of the ankle joint (Fig. 4). In one of the earliest cases in which the apparatus was used by one of my assistants, a pressure sore developed at this point, probably due, not to a badly applied turn of plaster, but to recoil of the limb within the plaster after release of the traction. In order to obviate this with certainty, we have always cut a small window at the point where recoil will cause greatest pressure.

The traction is now released, the knee straightened to twenty degrees short of full extension, and the plaster continued to the upper thigh. The pin is withdrawn from the os calcis after resterilizing the projecting part with iodin, and the plaster is completed over the heel (Fig. 5).

COMPLICATIONS

Impairment of Circulation

Over 100 cases of fracture of both leg bones have been reduced with this traction apparatus by the author and many assistants and colleagues (Figs. 6-A to 10-B). With the single exception of the early case referred to, no complication has ever arisen. The circulation in the toes is always carefully observed, but it has not yet been found necessary to cut down the plaster. While the plaster is actually being applied and the limb is

in heavy traction, it is obvious that the popliteal artery will be temporarily obliterated and there will be no circulation in the foot. This is restored, however, as soon as the traction is released, and before the plaster is continued to the upper thigh. We have seen no ill effects from pressure against the thigh support.

First Aid Measures

Fractures are reduced and put up in plaster at once, at whatever stage they may be when first seen. If for reasons of personal convenience a case cannot be immediately reduced, the fracture hematoma is injected with fifteen cubic centimeters of two per cent. novocain in order to relieve pain and shock, and a firm flannel bandage is applied from the toes to the knee in order to prevent swelling from appearing. If swelling is allowed to appear, it will not only be difficult to feel the fragments when reduction is attempted, but the plaster will become very slack in two or three weeks and may allow angulation to reappear.

Is Swelling a Contra-Indication?

The fear of swelling has, in the past, dominated treatment to an unreasonable extent. The only swelling which need cause real anxiety is that due to bleeding from a torn tibial artery, and in this case the tibial pulse is already weak or obliterated, the foot cold and blue, and the diagnosis obvious. In all other cases the swelling is simply due to mild hemorrhage from the fractured surfaces with traumatic oedema, and both factors are entirely within the control of firm external support. A plaster applied before the onset of swelling will prevent it from appearing, and there is very little likelihood of the pressure within the plaster being raised to the point of impairment of circulation. Care in observing the color of the toes is all that is necessary to avoid a catastrophe. If it is safe to apply plaster before the limb is swollen, it is obviously still more safe to apply it after swelling has appeared, and lack of thought is the only excuse for the claim so often made that a limb "was too swollen to do anything".

Is Blistering a Contra-Indication?

The old objection that blistering may appear twenty-four hours later and pass unrecognized if the limb is already encased in plaster, is still more fallacious. Skin blistering in the region of a fracture is due to oedema of the cuticle, and appears only when there is no external support, or when the external support is unequal. If two lateral splints have been applied to a leg, blisters will develop in front and behind, between the splints, but not beneath them. If the external pressure is quite uniform and regular, as is the case with a properly applied plaster, blisters never appear. If the fracture is of more than twenty-four hours' duration and blisters have already developed, they should be evacuated, dusted over with talc, and the plaster applied as before. Unless secondarily infected, they are always aseptic and will be quite healed when the plaster is

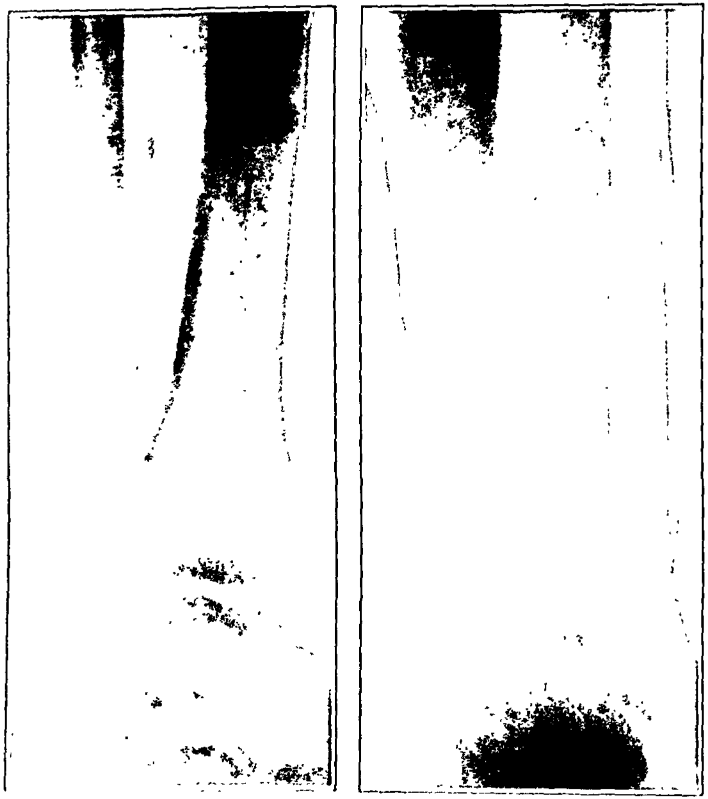

FIG. 7-A

Transverse fracture of both leg bones with overriding.

FIG. 7-B

After reduction (through plaster). After perfect apposition had been secured with heavy traction, the fragments were allowed to impact by slightly reducing the traction before applying plaster. It is unwise to do this in spiral or oblique fractures.

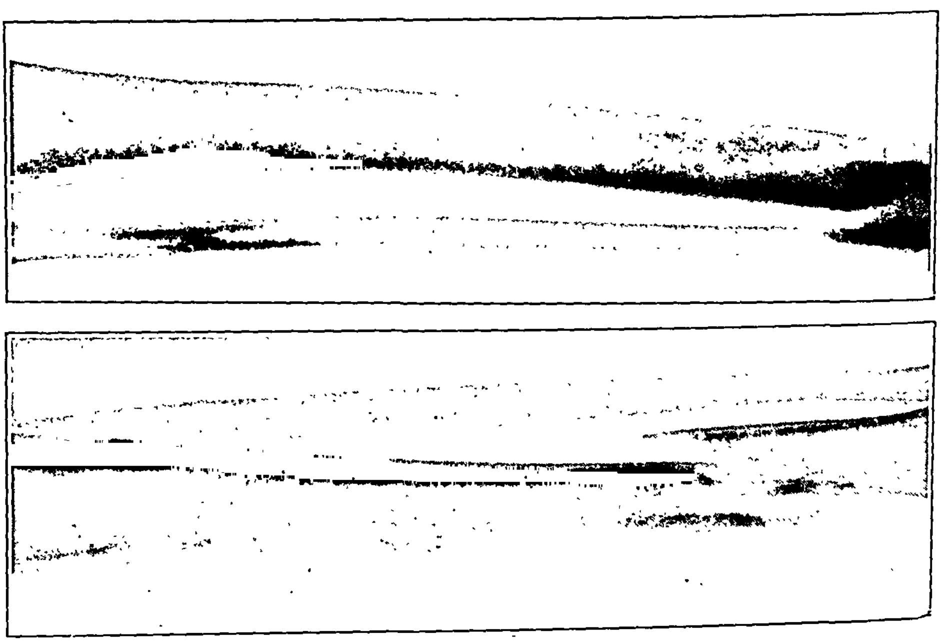

FIG. 8-A
Spiral fracture of both leg bones with overriding.

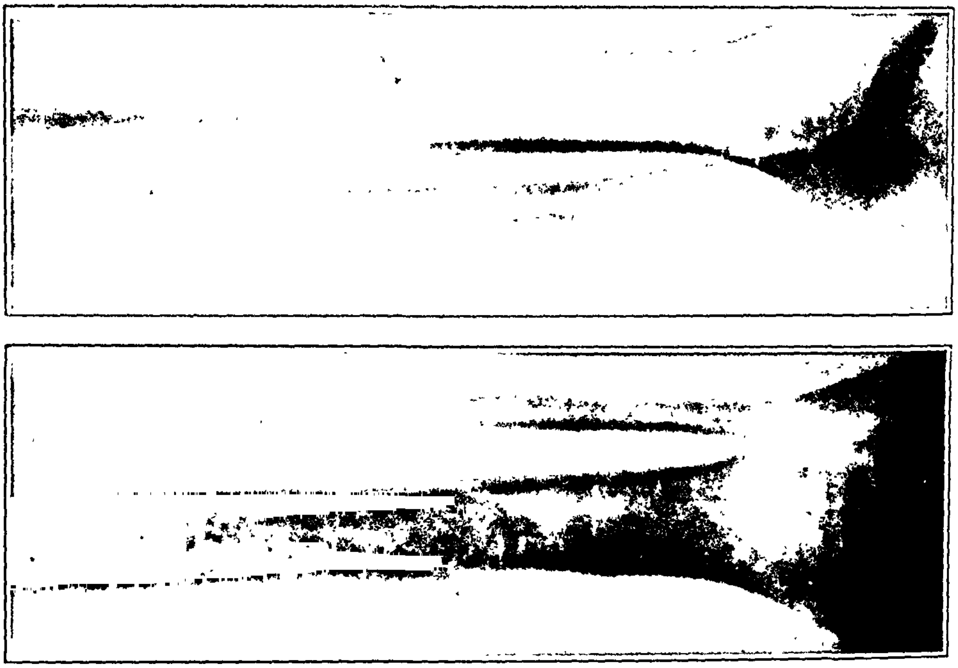

FIG. 8-B
Spiral fracture after reduction (through plaster).

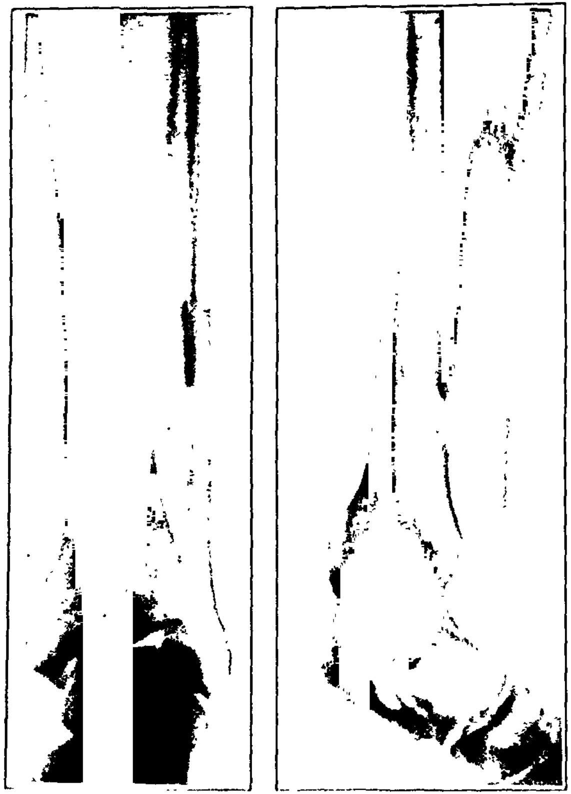

FIG. 9-A

Low oblique fracture of both leg bones with overriding. Without the tibia traction apparatus this is a very difficult fracture to treat conservatively, because the fragments redisplace as soon as the foot is dorsiflexed at the ankle joint

FIG. 9-B

Oblique fracture after reduction (through plaster). The slight inward and backward angulation was corrected by wedging the plaster (see text).

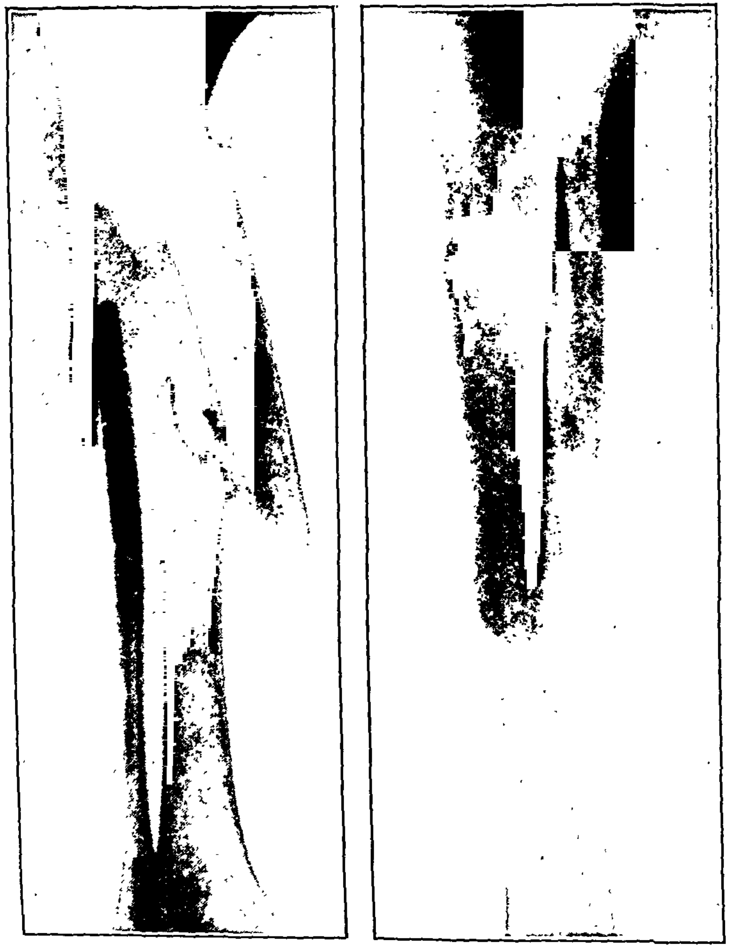

Fig. 10-A

Six-months-old compound fracture of both leg bones. The distal and middle fragments were plated together, skeletal traction maintained for fourteen days, and the limb then put up in plaster, and the plate removed through a window.

Fig. 10-B

The end result of a six-months-old compound, malunited fracture.

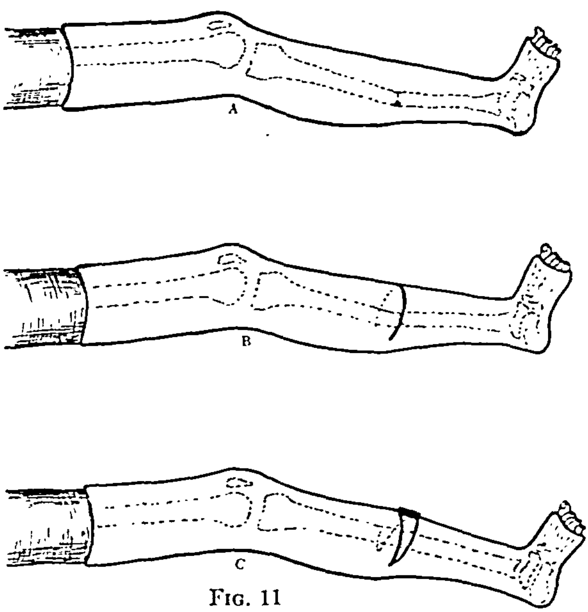

FIG. 11

FIG. 11

A method of wedging plasters, allowing correction of slight angulation with perfect control. A linear cut around two-thirds of the circumference of the plaster on the concave side of the angulation (*B*) is opened to a wedge (*C*). A block of wood is inserted and a roentgenogram taken. Undercorrection or overcorrection is controlled by increasing or decreasing the size of the block of wood. The block is moved nearer to the side or nearer to the front, according to whether the remaining angulation is mainly lateral or mainly anteroposterior. When the roentgenogram shows perfect alignment, the plaster is repaired and the block of wood incorporated.

removed. However extensive and severe blisters may be, no windows should be cut, because the lack of support will cause further oedema and blistering, and repeated dressings can only cause infection.

X-RAY CONTROL OF REDUCTION AND WEDGING OF PLASTERS

Immediate X-ray

It is, of course, of primary importance that the success of reduction should be confirmed at once by anteroposterior and lateral roentgenograms taken through the plaster. The films must include the whole length of the bones in order to detect the slightest degree of angulation.

Wedging of Plaster

If the technique has been faulty and any angulation remains, this should be corrected by wedging the plaster, however trivial the degree of deformity may appear. It is not advisable to cut out a wedge of plaster and close the gap together, because this involves some risk of a pressure sore. A linear cut should be made around two-thirds of the circumference of the plaster at the level of the fracture on the *concave* side of the angle. The linear division is opened to a wedge, and a small block of wood, one-third of an inch thick and one inch wide, is placed between the two cut edges (Fig. 11). The depth of the block of wood will vary according to the correction required. A very short gas anaesthetic may be used for the actual manipulation. The block of wood must be exactly opposite the angle—in front of the leg for backward angulation, on the inner side for outward angulation, half-way between the two for both backward and outward angulation, and so on. Before the plaster is repaired another roentgenogram is taken, and if necessary the degree of correction increased

or decreased by inserting larger or smaller blocks. When the alignment is quite perfect, the gap in the plaster is filled and reenforced.

Correction of Overlengthening

If the x-ray shows that, although alignment and apposition are perfect, the limb has been overlengthened by a quarter or a third of an inch, the plaster should be cut around the whole of its circumference in the middle third of the leg (not necessarily at the level of the fracture), the gap made by the plaster shears closed with direct vertical pressure, and the plaster repaired.

AFTER-TREATMENT

Ambulatory Treatment

Weight-bearing is a very necessary factor in prevention of disuse changes, and in the acceleration of consolidation. Provided that apposition is strictly end-to-end, that the fracture line is not too oblique, and that the plaster is still closely fitting, patients should walk freely, bearing weight on the limb from the second or third week. With very oblique fractures it is wise to defer weight-bearing until the sixth week. If the plaster is applied to a very swollen limb, in three weeks' time it will be too slack for weight-bearing to be safe. In this case, a new unpadded plaster is applied during the sixth week, and weight-bearing is then commenced.

FIG. 12

The patient may walk in three weeks. Normal dress is worn with a special plaster boot. Note the sorbo heel incorporated in the plaster, to avoid the jar of weight-bearing.

Advantages of a Rubber Heel in the Plaster

The incorporation of a sorbo rubber heel in the plaster avoids the jar of weight-bearing, and frequently patients who could not otherwise be persuaded to walk will do so with ease and comfort. The rubber adds a certain spring to the gait. The rubber should be applied outside the ordinary plaster and held in position beneath the heel with a few turns of plaster bandage. It must be emphasized that ambulatory treatment does not mean that the patient hobbles about on crutches carrying the injured limb. Although he may be allowed one crutch for a day or two, he must ultimately walk with no more assistance than that of a single stick (Fig. 12).

Plaster Boot

The incorporation of a metal stirrup such as that advised by Böhler is not advisable. Not only does the stirrup fail to relieve the jar of weight-bearing but it prevents the wearing of a boot, and no patient will walk about the streets of a city unless his dress is more or less

normal. For a few shillings a cloth boot can be made to cover the plaster, and the patient who cannot afford a special plaster boot can improvise one from a galoshe.

Treatment of Delayed Union

In eight weeks from the date of injury, the plaster is cut down and the degree of union estimated by a gentle clinical examination. If the fracture is firmly consolidated, no further immobilization is necessary. As a rule, however, it is advisable to reapply an unpadded plaster to just below the knee joint, and the patient continues to walk and to practise exercises for the recovery of knee movement. This plaster is removed and union tested at intervals, according to the degree of consolidation which had been found at the last examination. Most fractures are consolidated in ten weeks from the date of injury. In cases of delayed union, the fixation is continued as long as necessary up to four or five months. With such a routine it is practically never necessary to operate for non-union, even where the fracture has been infected. The practice of prescribing massage, percussion, damming and other physiotherapeutic measures is in our opinion definitely harmful. The essential factor in securing consolidation is constant, unremitting, and absolute fixation of the fragments on each other, while, at the same time, disuse changes are prevented by continued functional activity. Even occasional sheering or straining movements will still further delay union, and such is inevitable if the limb is daily lifted out of plaster to dam and hammer it. With such treatment, deformity is not infrequently allowed to appear, although in the earlier stages it was prevented with complete success.

Inefficiency of Ambulatory Splints

A short iron and T strap is never used as a convalescent brace. Either the fracture is so firmly consolidated that the iron is unnecessary, or it is not consolidated and, therefore, demands protection from *any* angulation, and not simply protection from inward angulation. Unlike the plaster cast below the knee, an outside iron and inside T strap do nothing to prevent backward angulation. Not only so, but cases may often be seen where bandaging an unsoundly consolidated fracture to an outside iron has actually produced outward angulation.

Inefficiency of Delbet Plaster

The Delbet plaster is equally unsound in principle and in practice. The fixation afforded by such a plaster is definitely inferior to that of a complete cast, and the inequality of external support fails to control oedema. The circular turns of plaster below the knee and above the ankle may even aggravate the tendency to oedema. Not only does such oedema delay recovery, but it stimulates adhesion formation around the ankle, and the slight ankle movement permitted by the Delbet plaster is

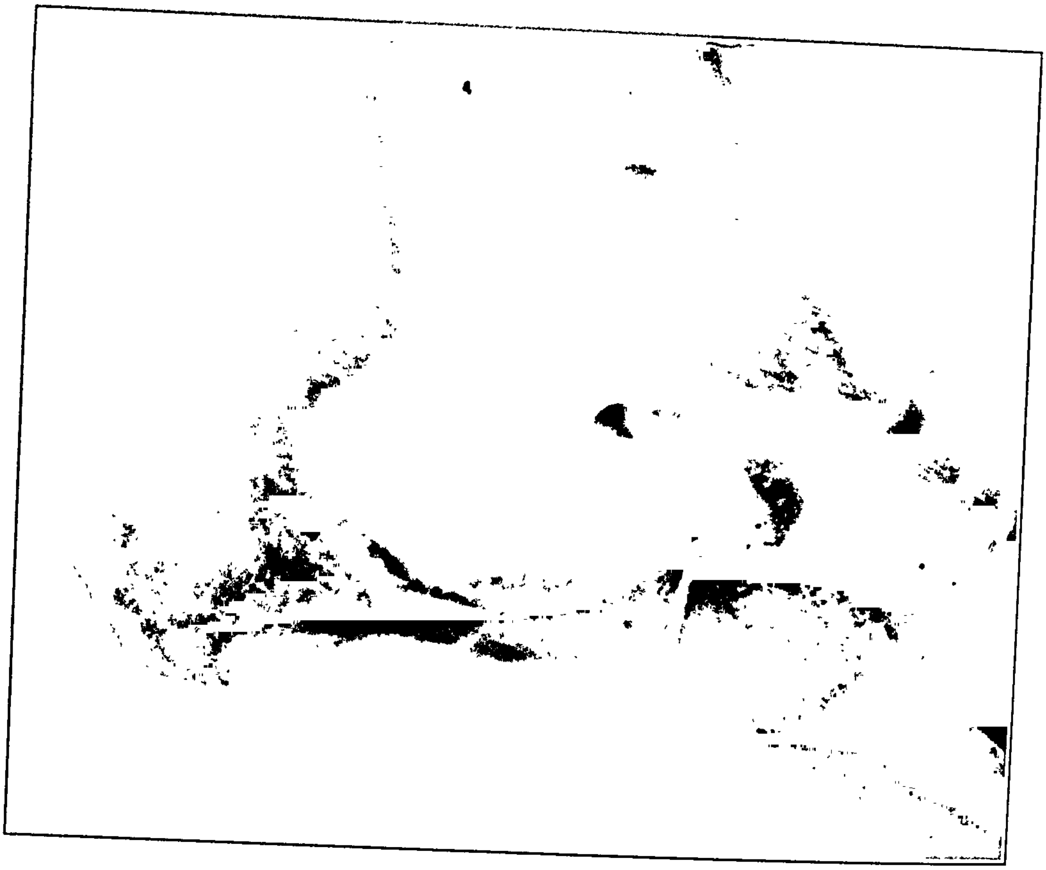

FIG. 13-A
Application of tibia traction apparatus to crush fractures of the os calcis. The pin is usually introduced above the os calcis just in front of the tendo achillis. Böhler's clamp reduces lateral spreading after the vertical crushing is corrected and while the limb is still in traction.

FIG. 13-B
Crush fracture of os calcis after reduction.

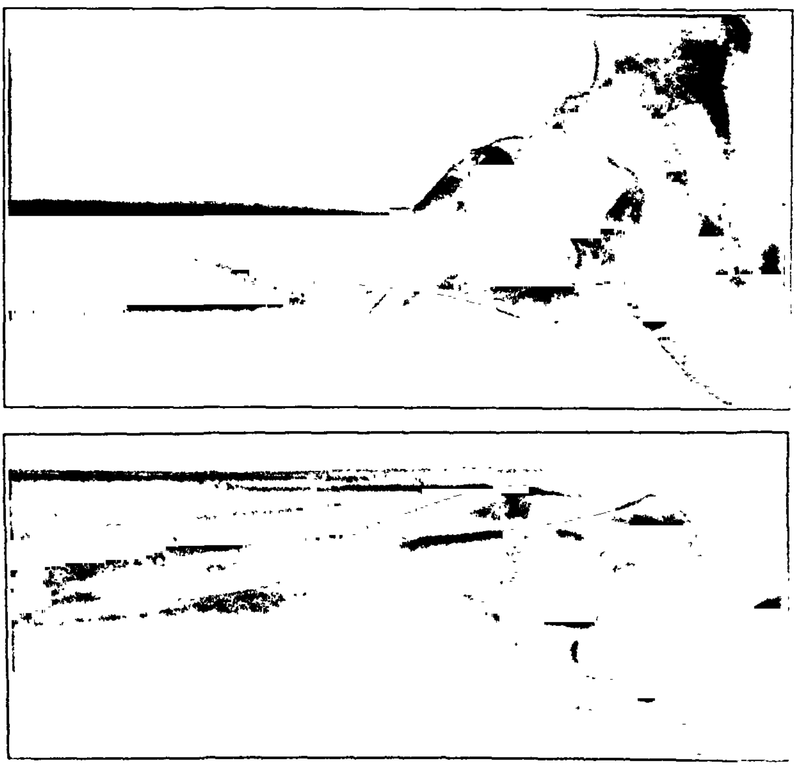

FIG. 14-A. Fracture-dislocation of ankle, with comminuted spiral fracture of tibia.

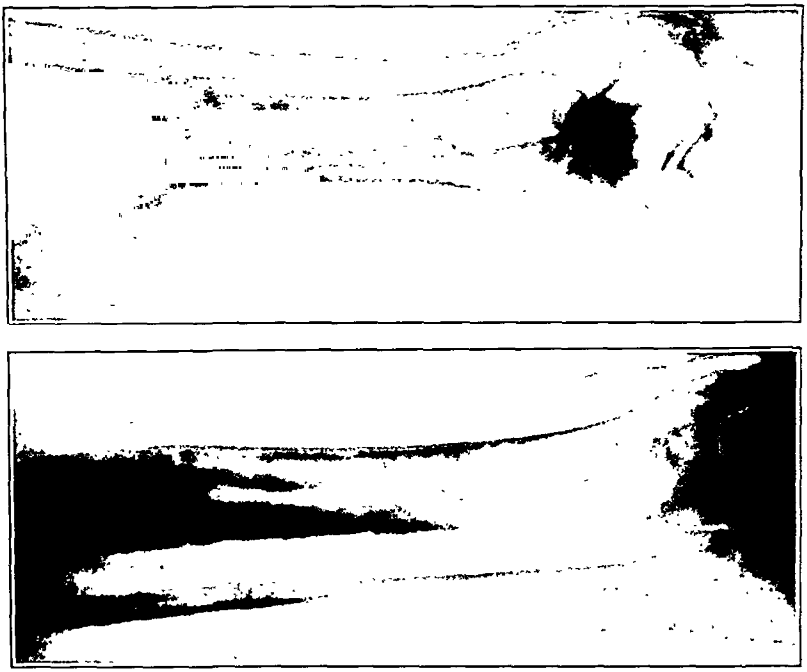

FIG. 14-B. Same case after reduction (through plaster).

insufficient to prevent this. Finally, the development of muscle tone is just as efficiently maintained by constant walking in a complete cast as by constant walking in a Delbet cast.

Prevention of Recurring Oedema

It is important that recurrent oedema of the leg after removal of the plaster should be prevented. The oedema is due to leakage of fluid from the small vessels into the tissue spaces, and is a result of hypotonicity of the musculature of the limb, and particularly of the musculature of the arterioles. However frequently the fluid may be dispersed by massage, it will continue to recur until the muscle tone has fully recovered. Although in the healthy young adult control may be rapidly established, in other patients a persistent and even progressive complication arises. Every time that the serum is allowed to escape, the track is distended and made more patent. Not only so, but the weight and discomfort of the swollen oedematous limb may be so great that the exercise necessary for its control is impossible, and a vicious circle is established. Many months of disability result, and simple oedema of hypotonic musculature may be seen as long as two years after fracture.

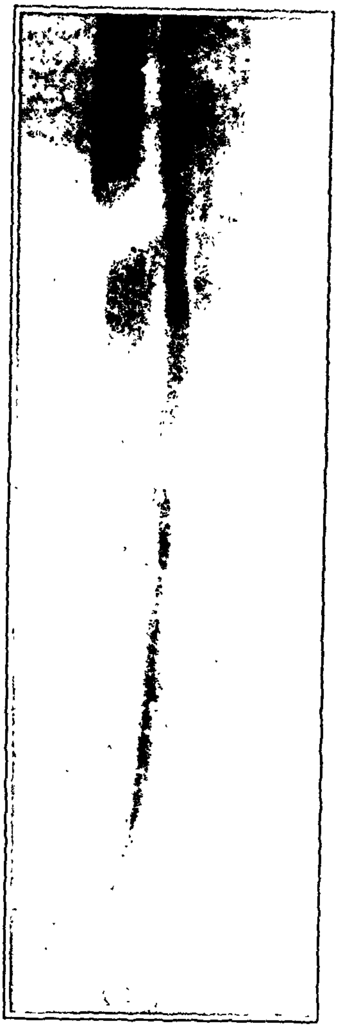

Fig. 15

Application of tibia traction apparatus in bone-lengthening operations on tibia. In this case one inch of lengthening was required. This was secured by Abbott's method in ten days, and plaster was then applied with the limb in traction.

Massage for twenty or thirty minutes daily, though capable of temporary dispersal of the fluid, is no substitute for the patient's exercise throughout his ten or fifteen waking hours, and as a rule physiotherapy does nothing more than to prevent progress of the disorder. The essential treatment is to prevent the oedema from ever appearing, while at the same time the patient develops his musculature by constant exercise. Ambulatory treatment has already gone far in this direction, and the wearing of a suitable support, firm enough to prevent swelling but not rigid enough to prevent movement, for six weeks after discarding the plaster will establish control. A crêpe bandage is unsuitable because it becomes loose and, if badly applied, may even aggravate the oedema by being too tightly applied around the upper calf. Böhler's zinc-gelatine-paste demands considerable time in preparation and application. Bandages already impregnated with Unna's paste, in the proprietary form known as the "Viscopaste" bandage, provide an ideal medium, which is always ready, requiring no preparation, and giving just sufficient support without immobilization. As soon as the plaster is cut off, a viscopaste bandage is applied, and is

retained until the patient recognizes that it is no tighter at the end of the day than it was at the beginning. No massage or physiotherapy is necessary and months of disability are avoided.

Treatment of Adhesions around the Ankle Joint

Throughout the time that the viscopaste bandage is retained, inversion and circumduction movements of the ankle are practised at regular intervals each day. If, after six weeks, there is still limitation of inversion and plantar-flexion, with pain when these movements are performed passively, it is evident that adhesions are still present. Unless these adhesions are fully stretched they may persist indefinitely, and for years afterwards the patient complains vaguely of "weakness of the leg", "a feeling of giving way", and "difficulty in going downstairs". It is surprising with what constancy qualified surgeons will ignore such complaints, or advise rest, or attribute the symptoms to arthritis of the ankle, or dismiss them as the inevitable penalty of fractures of the leg or ankle. Very frequently the patient drifts to a bone-setter, his disability is cured in ten days, and quite naturally he is much more grateful to the unqualified practitioner who completed his treatment than to the qualified surgeon who failed at the last stage only. If the patient has been unable to stretch the adhesions during six weeks of ankle exercise, they should be snapped by manipulation under a short anaesthetic. The important movements for the full stretching of residual adhesions are inversion of the heel, adduction of the forefoot, and plantar-flexion at the ankle and mid-tarsal joints.

APPLICATION OF THE METHOD TO COMPOUND FRACTURES

Within a Few Hours of Injury

If it is possible with safety to convert the compound into a closed fracture, this should be attempted. The method must not be attempted unless the case is seen within an hour or two of injury, and unless the primary débridement is complete. The skin is stitched and the fracture then reduced by means of the traction apparatus in the ordinary way. A window over the wound allows it to be exposed to the air, in order to give the maximum opportunity of drying and of healing by first intention.

Principles of Treatment of Definitely Infected Fractures

If the fracture is several days old and infection already established, or if primary excision and suture has failed, or if the operator doubts the efficiency of his primary excision, there can be little doubt that the no-dressing, Winnett Orr method offers the best chance of securing a limb indistinguishable from normal. Whether or not surgeons are prepared to agree as to the advisability of treating simple osteomyelitis by this method, it must be agreed that there is no other method which at the same time allows perfect fixation of the fracture with perfect control of the infection. One or the other element of the treatment usually receives preference and, as a rule, treatment is concentrated during the first month or two on the infection, while the position and the immobilization of the frag-

ments is regarded as of secondary importance. The view that infection is a cause of non-union is now well established. Actually, however, infection does nothing more than to delay union by the excessive decalcification of persistent hyperaemia. But, if during this time immobilization is interrupted or is imperfectly maintained, non-union results just as surely as it would result in a closed fracture which was imperfectly immobilized. The only difference is that in the closed fracture immobilization must be maintained for ten weeks, whereas in the infected fracture equally perfect immobilization must be maintained until the infection is quiescent and the wound healed, and for ten weeks longer. With this routine, the majority of infected fractures unite firmly by bone without the necessity of a bone-grafting operation.

Technique in Infected Fractures

The limb is fixed in the traction apparatus, the wound excised, necrotic and entirely loose fragments removed, and free drainage established. The saucerized wound is packed with vaselin gauze, the skin thoroughly protected with vaselin, and a padded plaster cast applied. The use of the traction apparatus makes it quite unnecessary to leave pins in the bone as recommended by Winnett Orr.

In four weeks a new plaster is applied and any sequestra which have separated are removed. Successive plasters are applied as necessary. When the granulated wound has epithelialized and is quite dry, an unpadded cast is applied and weight-bearing commenced, whatever degree of union may have developed. Successive roentgenograms show rapid refilling of cavities, and, after quiescence of infection, as weight-bearing is continued, rapid recalcification of the bones. The alignment and length of the limb having been maintained throughout, when consolidation is finally secured, it is unaccompanied by deformity or shortening.

CONCLUSION

A new tibia traction apparatus which is simple in construction, easily portable, and applicable anywhere under any circumstances, has been found in a large series of cases to be of the greatest value in treating overriding fractures of the shafts of the tibia and fibula. The surgeon experienced in its use may secure anatomical reduction without operative interference with almost unfailing constancy, and the most inexperienced amateur will find that the treatment of these otherwise difficult cases becomes greatly simplified.

The apparatus may also be used for the reduction of crush fractures of the os calcis (Figs. 13-A and 13-B), difficult Pott-Dupuytren fractures (Figs. 14-A and 14-B), and for the application of plaster after a bone-lengthening operation on the tibia (Fig. 15).

The development of the apparatus in its early stages and the general routine of treatment which has been described are the result of team-work, and the author would particularly record his indebtedness to the Orthopaedic Registrar at the Liverpool Royal Infirmary, Mr. W. Sayle Creer.

THE TREATMENT OF OSTEOMYELITIS IN THE WARM SALT-WATER POOL *

BY A. BROCKWAY, M.D., LOS ANGELES, CALIFORNIA

During the past few years there have been a number of new ideas advocated for the treatment of this very stubborn disease, and the writer would hesitate to present a still different outline of treatment, but for the fact that he is convinced that the method to be described here embodies certain definite principles in the treatment of infection and joint healing that makes it well worth bringing before the medical profession. While we have used the warm salt-water pool in all types of non-tuberculous osteomyelitis, it has its greatest field of usefulness in those cases where the involvement is in close proximity to the joint line or where the process involves the joint structure as well.

During the past four years, up until eight months ago, the Winnett Orr treatment has been used at the Orthopaedic Hospital with a great deal of satisfaction, a satisfaction that has been shared by many other men who have used it. This method of treatment has been highly successful because it satisfies the two cardinal principles in the treatment of infection,—namely, adequate drainage and local and general rest. If the diseased process extends close to or involves the joint, there is another principle of treatment that is not made use of in the Orr treatment. In osteomyelitis the acute stage soon reaches the subacute and chronic stage, and it is becoming more and more recognized that the best stimulation to healing in a diseased joint is physiological motion. Even if the suppurative process does not involve the joint proper, there is apt to be considerable loss of motion of the joint with the affected limb immobilized in plaster for a great length of time. In the treatment of arthritis in the chronic stage, it is becoming well recognized that it is extremely important to obtain active motion of joints even at the expense of a long drawn-out fight for both patient and surgeon, a struggle that is often very painful during the first stages, but in the end is rewarded by a painless arc of motion and a degree of regeneration of joint structures that can never be obtained by prolonged immobilization.

Treatment in the salt-water pool embodies the cardinal principles of drainage and rest during the acute stage when there is pain and temperature, and in addition makes early use of a third principle,—namely, that physiological stimulation of a disorganized joint is the most important factor in joint regeneration and reestablishment of joint motion.

In addition to this, the warm salt-water pool has other distinct advantages. In the first place the warmth of the water has a very definite and well recognized beneficial effect in the treatment of any infection. Also, the water being strongly hypertonic, there is an osmotic pressure

* From the Clinics of the Orthopaedic Hospital-School.

existing between the *body fluids and the salt water that creates an outflow* of body fluid, which insures a regular and efficient washing and cleansing of the wound from its innermost depths. The practical demonstration of the truth of this principle has been shown many times in the treatment of deep, badly infected soft-tissue wounds. After a few daily salt pool *treatments, these wounds clear up with surprising rapidity.*

There is still another advantage in this type of treatment, an advantage that is more than imaginary. These patients, especially the older ones, become very tired of lying for months in ill-smelling casts, and when they begin daily treatment in the pool there is a distinct improvement in the morale. *The treatments give them something definite and enjoyable* to do, and when, in addition, they can watch the weekly improvement of

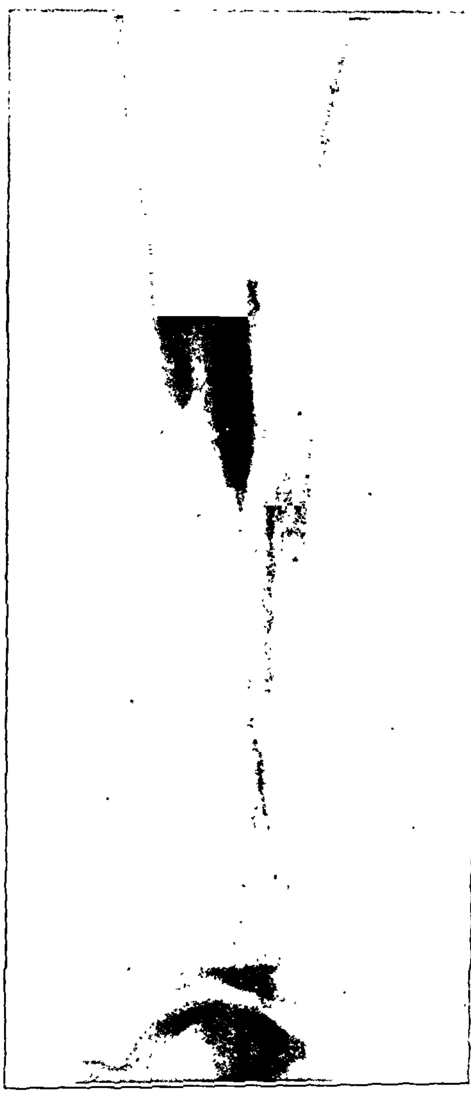

FIG. 1-A

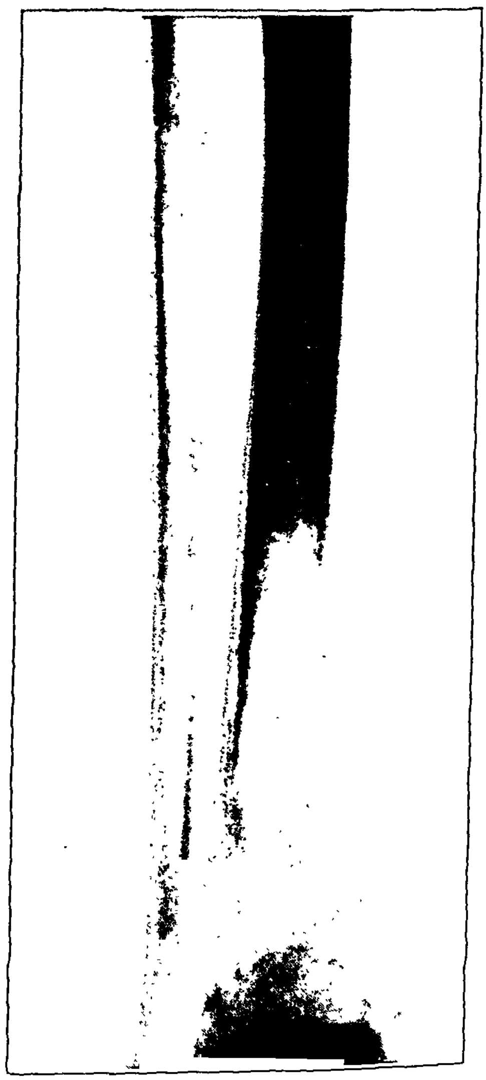

FIG. 1-B

Case 2. One week after operation. Notice that there is almost total absence of bony tissue for a distance of about two inches above the distal tibial epiphysis. In spite of this, motion of the ankle was started in the pool six weeks later, following which the drainage rapidly decreased.

their stiff joints and see their wounds become smaller and cleaner, the psychological effect is very evident.

In more detail, a case of osteomyelitis is handled as follows:

In the beginning the case is treated by the Winnett Orr method. The diseased bone is widely saucerized until healthy-appearing bone is encountered and the cavity and soft tissue lightly packed with vaselin gauze, and a plaster cast or spica applied. The length of time this cast is worn depends somewhat on the degree of bone destruction, the temperature and general appearance of the patient following operation, but, in general, for an average tibia or femur case, this cast remains for about a month. Then it is removed and daily pool treatment started, maintaining immobilization between treatments by means of bivalved casts or by

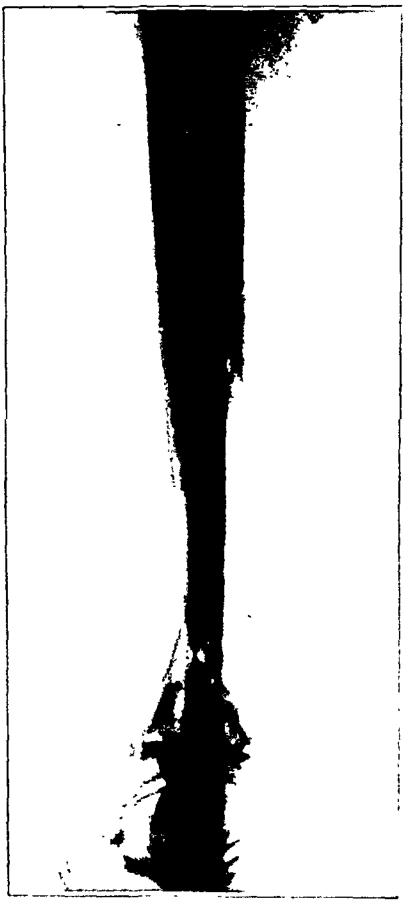

FIG. 2-A

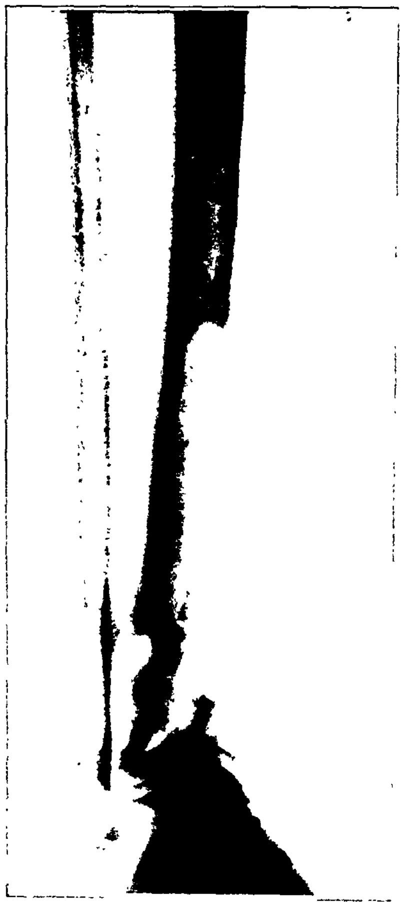

FIG. 2-B

Case 2. Four months after operation. Notice the marked regeneration of bone in relatively short space of time. The wound is now completely healed and the patient is walking on crutches without weight-bearing on this leg. There is about thirty degrees of motion in the ankle.

light traction. During the first few treatments a splint is sometimes worn if it is not thought safe to begin motion of the involved joint.

The concentration of the salt in the pool is about six or seven per cent., which is a little stronger than average sea water, and, with this concentration, cultures of the water have always been sterile. The arc of motion of the involved joint, or the joints adjacent to the involved shaft, can be made greater and with much less pain than motion made out of water, and there is no reaction of pain after the patient is removed from the pool: in fact, the patient always says that the leg feels much better after treatment.

Later on in the course of treatment, when beginning of partial weight-bearing is indicated, the use of the pool is ideal. The dosage of weight passing through the lower extremities can be easily and accurately measured, since this weight is only the weight of the body above the water line. When weight-bearing is first started, the patient begins walking in the deeper water and gradually the depth of the water is decreased.

Up to date eleven cases have been treated. The first case was a suppurative arthritis of the knee joint with no bone involvement. This case responded so well to treatment that we began to use the same method with osteomyelitis and so far have been very favorably impressed with the results. In the suppurative arthritis case the knee was opened wide with a longitudinal incision on either side of the patella and fifty cubic centimeters of pus evacuated. The next five days the knee was irrigated with normal salt solution and motion started by using a Thomas splint with a movable knee. Following this the patient was put in the warm salt-water pool daily and motion encouraged. At the end of two months the contour of the knee was practically normal, both wounds had healed, and the patient had started to walk without crutches. There was complete extension of the knee and flexion blocked at eighty degrees. At three months postoperative the patient had a full range of painless motion, with the patella freely movable, and he was walking without limp.

The next case was osteomyelitis of the lower third of the tibia. An operation had been performed on the leg by another surgeon two weeks before admission to our hospital. The x-ray showed complete absence of bone in the lower two inches of the tibia just above the epiphysis except for a little bony debris. Proximal to this there was a loss of bony tissue on the medial portion of the tibia for a distance of another three or four inches. Upon admission the wound was packed with vaselin gauze and a long leg plaster cast applied. Six weeks later the patient was started with daily pool treatment, using the bivalved cast for a splint between treatments. The discharge decreased rapidly in amount and in two months the wound was completely healed. X-rays taken four months after operation show a remarkable growth of new bone, considering the loss of bony tissue as shown by the x-ray taken two weeks following operation. The patient at this time has about thirty degrees of ankle-joint motion.

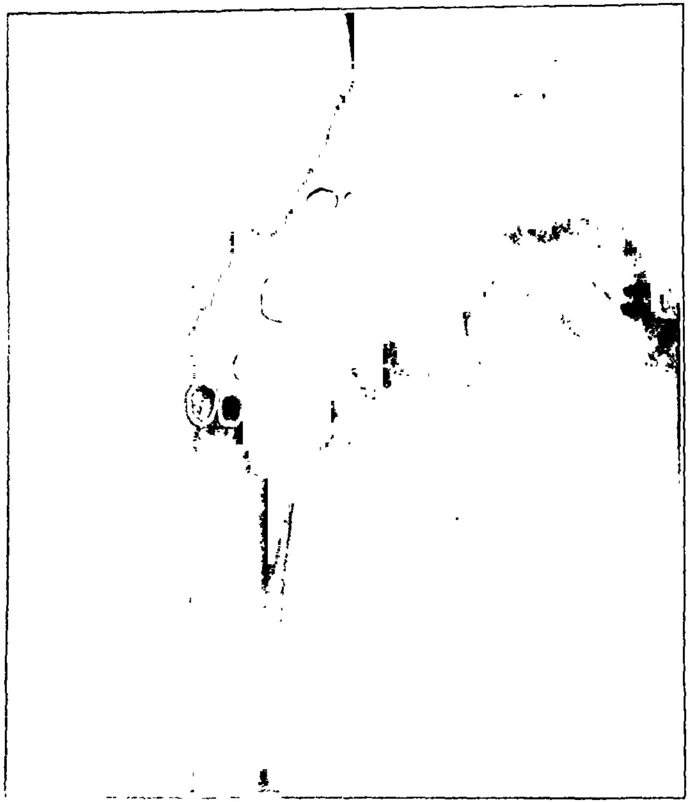

Fig. 3

Case 3. Acute onset of osteomyelitis in neck of right femur. There is bone destruction on the lateral aspect of the neck just below the epiphyseal line and just below the greater trochanter. Large drill holes were made upward through the neck, starting below the trochanter in order not to contaminate the hip joint. Wound packed with vaselin gauze and a long leg plaster spica applied which the patient wore for three weeks, after which daily warm salt pool treatment was started

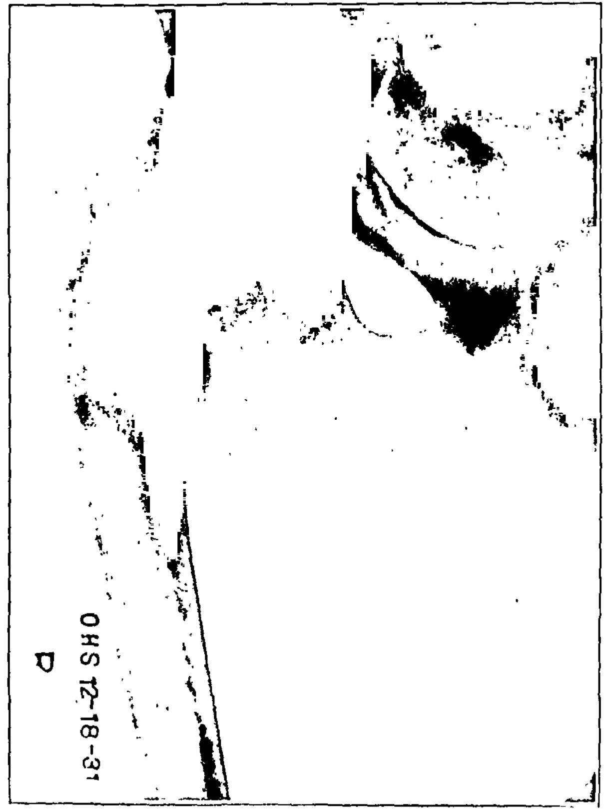

Fig. 4

Case 3. X-ray two months later shows considerably bone regeneration. The patient has ninety degrees' flexion in the hip, twenty-five degrees' abduction, and over half the range of normal rotation without pain.

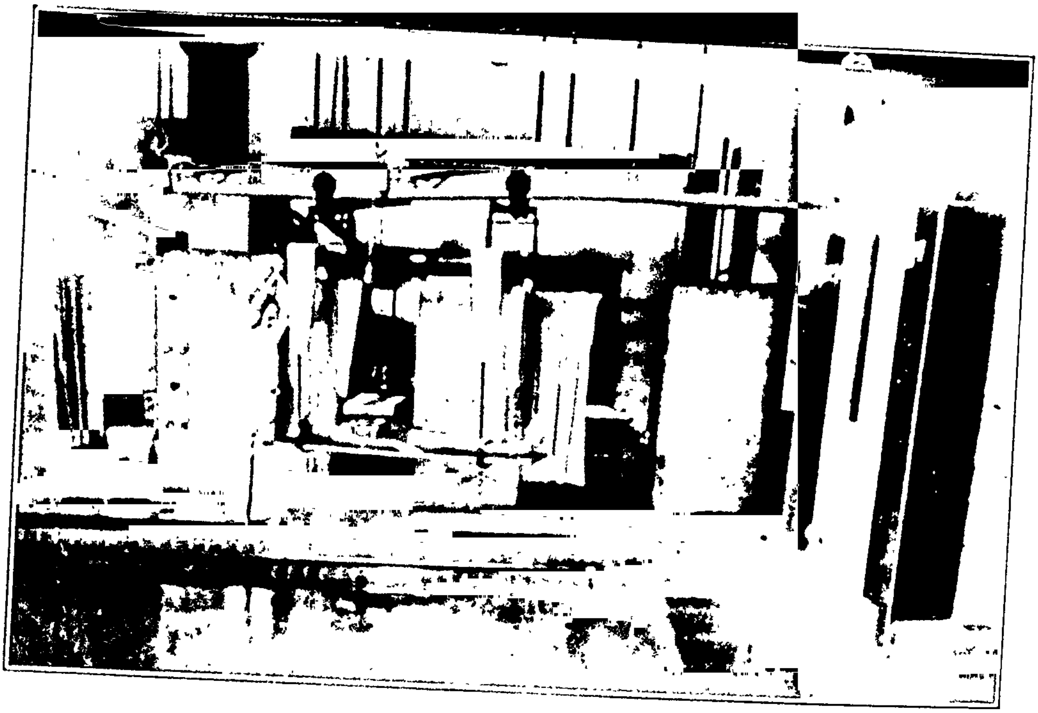

FIG. 5
Underwater gymnasium, Orthopaedic Hospital-School, Los Angeles, California. New method of handling recent and painful cases to and from the water.

Case 3. This was a sixteen-year-old boy who had an acute osteomyelitis of the left femur which was treated by Baer's maggot method. The wound was still draining when he suddenly began to have pain in the right hip with chill and high fever. The x-ray film showed an area of rarefaction just below the epiphyseal line of the capital epiphysis. There was also destruction of the lateral cortex of the femur beginning just below the greater trochanter and extending down the shaft for a distance of three or four inches. Six days after the clinical onset a femoral osteotomy was done and the neck of the femur drained by making large drill holes upward into the neck, starting below the trochanter in order not to contaminate the hip joint. The wound was packed with vaselin gauze and a long leg plaster spica applied. The spica was left on for three weeks during which time the temperature went up to 100 degrees daily. Light cuff traction to knee and ankle was then applied and daily pool treatment started. The temperature dropped to normal in a few days and the discharge rapidly decreased. X-rays of the hip two months later show definite bone regeneration and the wound healed except for one small point which was covered by excess granulations and was draining hardly at all. The patient at this time had no pain on motion of the hip and had almost ninety degrees of flexion, twenty-five degrees of abduction, complete adduction, complete internal rotation, and external rotation to a little past neutral position.

Eight other cases of osteomyelitis have been treated in this fashion, but it is too early to give end results. There were several patients in this group who were being treated by the Orr method who were still draining

moderately to profusely. In each case where the pool treatment was substituted there was a rapid diminution of drainage and a lowering of the temperature curve. One case now under treatment was osteomyelitis of the lower end of the tibia and fibula with involvement of the ankle joint. The ankle was laid wide open and packed with vaselin gauze and immobilized in plaster. The temperature gradually subsided, but within ten days there was a sudden rise of temperature with severe pain. The wound was then repacked under a general anaesthetic, and the temperature dropped again to almost normal and then suddenly became elevated again and the patient looked acutely ill. The plaster cast was then removed and daily pool treatment started. Within a week there was a marked diminution of pus, the temperature became normal and has remained so since; the patient is free of all pain, his appetite is good: and he looks like a different boy.

SUMMARY

Eleven cases of osteomyelitis have been treated in the warm salt-water pool. Theoretically, the principles of treatment seem sound and by actual practice the method has given worth-while results. It is particularly suited to those cases where the osteomyelitic process involves the joint or is in close proximity to the joint.

This method of treatment embodies and makes use of definite well recognized principles in the treatment of infection and joint regeneration.—namely:

1. Adequate drainage and immobilization. After the acute stage absolute rest is not maintained, but after the first month the plaster cast is removed and the patient immobilized in bed by light traction, by splints, or by bivalved casts. Daily pool treatment is then started, but even this is comparative rest, since motions in the pool are performed with a minimum of effort. No effort is exerted by the patient in getting in and out of the pool, since this work is done by an overhead electric traveling hoist with the patient lying on a stretcher.

2. Past experience in the treatment of suppurative arthritis has proven the proposition that physiological stimulation of a joint is the best means of insuring maximum return of motion in a diseased joint and a regeneration of joint structure. This principle is made use of in the salt-water pool treatment without jeopardizing the cardinal principle of rest.

3. The salt solution being strongly hypertonic, drainage of the infected tissue is accelerated because the difference in osmotic pressure existing between the solution and the body fluids causes an outflow of the latter from the diseased area.

4. Active movement in the water avoids the production of inhibitory spasm from pain or fear of pain as is usually produced by other forms of physiotherapy and muscle reeducation movements.

5. The treatment is soothing and is enjoyed by the patient, as compared with spending months of inactivity in ill-smelling casts.

FLEXION CONTRACTURE OF THE KNEE

The Mechanics of the Muscular Contracture and the Turnbuckle Cast Method of Treatment; with a Review of Fifty-Five Cases*

BY JACOB KULOWSKI, M.D., IOWA CITY, IOWA

Flexion contracture of the knee, like all other similar situations of the body involving the muscles, bones, joints, and ligaments, is subordinate to the same biophysical laws enunciated by Steindler in relation to the wrist and fingers. Its analysis involves a consideration of the concomitant gliding and rotatory motions of the joint that are an essential part of the normal mechanics of flexion.

The knee is the largest and most complicated joint of the body. It is a trocho-ginglymus, and allows rotation about a vertical axis, as well as flexion and extension. "Its peculiar anatomic construction is an expression of the very exacting static and dynamic requirements which it must meet, because of its situation between the hip and ankle joints in the middle of the weight-supporting lower extremity" (Steindler). It will be shown that the abnormal new point of muscular equilibrium, which is the position of contracture, is dependent upon the normal mechanics of the knee, and follows definite physical laws.

Flexion contracture of the knee presents postural deviations in the three cardinal planes of the body, as a rule. In the sagittal plane there is the predominant flexion position and the usual posterior subluxation of the tibia on the femur. The frontal plane abnormality expresses itself in increased valgus, while the external rotation of the tibia takes place in the horizontal plane.

1. *The Situation in the Sagittal Plane:*

The mid-position of the knee is in moderate flexion, in which attitude the muscles about the joint are nearest their point of equilibrium. There is then an inherent tendency of the joint to assume flexion, especially during relaxation. In full extension the hamstrings are under a stretch and are, for that reason, in the optimum condition for contraction. Reflex irritation therefore anticipates prevailing action of the hamstrings.

Clinically, and by hydrostatic experiments, it is known that the greatest capacity of the knee joint capsule is in the position of flexion. Excessive amounts of fluid in the joint will then naturally dictate the flexion posture.

In flexion of the knee the initial twenty degrees is a pure rocking motion, and is completed by a gliding motion of the tibia upon the femur. Subluxation of the tibia, therefore, occurs at some point of the gliding range of the joint.

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2. *The Situation in the Frontal Plane:*

The knee normally has an appreciable valgus. Any increase of this angle is associated with the mechanogenesis of pathological external rotation. The tensor fasciae and the biceps femoris are external rotators of the knee; contracture of either or both tends also to increase the valgus.

The peripheral resistance incident to weight-bearing in the usual externally rotated position upon a flexed knee tends to increase the valgus. This is also remarkable in knee joints that have been fused by operation in the position of flexion. Many of these develop a valgus deformity, especially in children. A "closed kinetic chain" may result even from recumbency, because of the usual attitude of inward rotation of the thighs assumed by arthritics, who have more or less involvement of the lower extremity.

3. *The Situation in the Horizontal Plane:*

The biceps femoris acts upon the tibia through a longer lever arm than the internal hamstrings, because it is more distally inserted from the center of rotation of the knee, the vertical axis of which passes through the medial condyle of the tibia. The moment of the externally rotating forces is then the greater. Other factors favoring external rotation during flexion are: the relaxation of the ligamentous structures, the unwinding action of the crucial ligaments, and the loose attachment of the external meniscus.

It is, therefore, evident that the key to the contracture complex is the flexion position. The associated elements are secondary phenomena directly dependent upon it. The contracture position is, therefore, a fixed exaggeration of the normal flexion mechanics of the knee, incident to the newly established muscular equilibrium, and is certainly not a haphazard event.

Clinically, the contractures of the knee may be classified as:

1. *Arthrogenic.* This is by far the largest group as well as the most important one to be considered. Here are included all the contractures due to some primary joint pathology. The reflex irritations and hydrostatics are the predominant causes of deformity.

2. *Hypertonic.* Muscular imbalance, due to increased innervational impulses as in spastic paralysis and similar conditions, is the causal factor in this group.

3. *Paralytic.* This type is primarily due to muscular imbalance following paralysis or weakness of the antagonistic group, which in this case is the quadriceps. It may also be secondary to hip and ankle deformities.

4. *Congenital.*

5. *Postural.* These are secondary, due to static causes brought on by flexion contracture of the hip and disturbances of gastrocnemius function.

6. *Myositic.* This group is rare but may follow in the wake of

histopathological *changes in the muscles from actual inflammatory involvement of the muscles.*

The method of gradual correction of flexion contractures of the knee is indicated in the great majority of cases, and is actually effective. This view is amply supported by clinical and experimental observations upon muscular contracture. However, nothing is known of the biophysical properties of the capsular, nervous, and vascular structures which play such a prominent rôle in the posterior part of the knee. This naturally limits the application of conservative methods.

The importance of the posterior capsule in certain contractures of the knee cannot be overemphasized. Silver very aptly designated all the soft structures of the joint as the "surgical capsule".

Clinically, the block due to capsular shrinkage can be determined by the presence of a posterior springy resistance against passive extension of the knee in the presence of relaxed hamstrings. This has been confirmed at operation. In several such instances the complete relaxation of the muscles in the face of a markedly contracted capsule was remarkable. The muscles and tendons contiguous to the capsule do exhibit some shrinkage, while those more superficially placed are actually flaccid, even though they are a part of the same functional group. This is particularly true of the semimembranosus, because it has several broad aponeurotic insertions in and about the capsule. Similar observations, in principle, have been made in contractures of the hip joint.

The writer is convinced that capsular involvement precludes the mechanical method of correction by the present means at our disposal. In such cases the stripping of the capsule by the method of Silver or Wilson yields excellent results. Fortunately the capsule is, in most cases, the last structure to take part in the contracture. It is the writer's opinion that posterior capsular shrinkage does not occur in pure myogenetic contractures unless a very long period has elapsed. Among the many tenotomies that have been performed in this clinic, surprisingly few cases required additional capsulotomy. Actual inflammatory involvement of the capsule is the usual cause of capsular contracture, and such changes have been described in the literature.

Regarding the vascular and nervous structures even less can be said. If these cannot be accommodated to full extension, all corrective measures must be abandoned, save those that will shorten the extremity, as joint resection. But clinical experience teaches that, in practically all cases, these do respond to gradual correction.

Steindler called attention to the hypertrophied infrapatellar fat pad as a primary cause of flexion deformity, and anterior mechanical block to extension. In reviewing about sixty synovectomies performed in this clinic, the writer noted twelve cases of flexion contracture that resulted in full extension following operation.

The contra-indications to conservative gradual correction may be summed up as follows: (1) intra-articular adhesions and ankylosis, (2) all

varieties of internal mechanical blocks, (3) active joint disease, (4) posterior capsular shrinkage, (5) extreme structural changes in the hamstrings, and (6) local conditions of the skin that prohibit the application of force.

It is unreservedly admitted that operative procedures have a definite field of indication in the treatment of knee-joint contractures. Tendon lengthening, stripping of the hamstrings from their point of origin, juxta-articular osteotomies, arthroplasty, alcohol injections of the peripheral nerves, resection of the joint, capsulotomy, capsuloplasty, and tendon transplantation are necessary in selected cases. Some of these procedures merely place the joint in a more favorable position for action.

A word of caution relative to open operative and closed manipulative (redressment force) methods, upon arthrogenic contractures especially, is imperative. Many of these patients are elderly and are poor operative risks because of the general pathological changes underlying the local cause of invalidism. The atrophic condition of the bones favors post-operative infection and fracture. Several such instances of infection with erosion of the popliteal vessels have been observed. Two cases of fat embolism resulted from the fractures incident to manual corrective attempts.

Autopsy examinations revealed extensive parenchymatous pathological changes, the occurrence of which is too often overlooked in chronic arthritis. These cases combine all the optimum conditions for fat embolism in orthopaedic manipulations. The initial force drives the fat into the numerous vascular channels, because abundance of fat and vascularity are both characteristic of atrophic bone. In one case the fragility of the bones was dramatically demonstrated at autopsy, when the long bones were fractured with a minimum of effort. This complication is so insidious that it is often unsuspected until the symptoms of embolism make their grim appearance. Primary manipulation of arthritic joints has not been performed in this clinic for the past ten years.

The many mechanical appliances that have been devised for the gradual correction of flexion contractures of the knee are a tribute to conservatism. Those in use by Campbell, Smith, Lord, and others have much to recommend them, but usually require the construction of special apparatus. Their chief feature is directed against posterior subluxation already present, and its prevention during treatment. Juckelson states that the turnbuckle of Hackenbruch (*Distraktionsklammer*) was introduced in connection with the lower extremity in 1913. All joint contractures are treated by the turnbuckle method in this clinic wherever feasible. The elbow and the knee are by nature best adapted to this method.

The knee is situated in the center of two long levers with the joint as the axis of rotation. The turnbuckle-cast method depends upon the principle of three-point application of force. The principles of the second-class lever are utilized. It is absolutely essential that the joint remains the axis of motion of the system. The leg is considered to be the movable body. The moment of leverage is dependent upon the amount of force

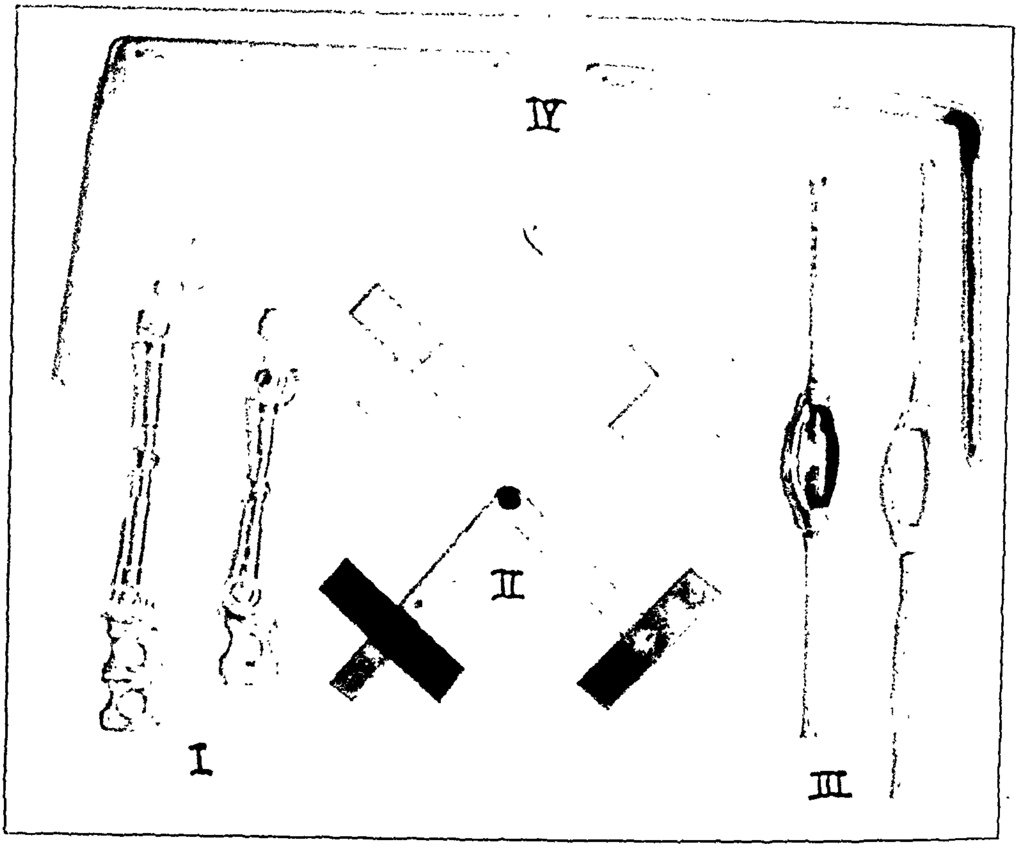

FIG. 1

I. Hackenbruch type of turnbuckle, which has ball and socket joints at the junction of the flanges and posts. Both halves are united by a sleeve-screw device which is perforated to allow insertion of lever for turning the turnbuckle.

II. Steel hinge with band on each end.

III. Ordinary buck-saw type of turnbuckle. (A windlass arrangement may be used.)

IV. Piece of cold rolled steel, three-sixteenths by seven-eighths inches, bent at right angles.

the angle of application, and its perpendicular distance from the center of rotation. The resistance to be overcome is the hamstring contracture as well as the weight of the leg. The possibility of initiating posterior subluxation (or increasing it, if it is already present) of the tibia must be considered in the practical application of this methed.

If the force is applied distal to the insertion of the hamstrings and its resistance cannot be overcome, their point of insertion will become the center of rotation, with a resultant posterior dislocation of the upper end of the tibia.

When the resistance of the hamstrings is overcome, the center of rotation remains at the knee joint, and the leg rotates forward. The incorporation of hinges into the cast serves to maintain the center of motion at the joint. The correcting force resolves itself into a forward and a traction component. If a sliding type of hinge is used, the latter component may be utilized with advantage upon arthritic joints.

Mechanically, as correction proceeds, it becomes more difficult to overcome the resistance due to the decreasing angle of application. This

contingency is met by placing the turnbuckles anteriorly, fixed to uprights incorporated in the cast. In this way a better purchase is obtained for the last few degrees of correction (Quengel method of Mommsen). Eccentrically placed turnbuckles easily overcome the external rotatory deformity before the hinges are included in the cast. By placing the hinges behind the center of motion of the knee, a forward thrust is exerted upon the upper border of the tibia, which tends to correct the subluxation.

The turnbuckle-cast method, in its several parts, is extremely simple. As a method of systematic procedure, attention to details is essential to obtain the best results.

The patella offers the counter-pressure to that which is applied posteriorly upon the thigh and leg. These areas require adequate protection. Special care is taken about the heel. A long leg cast is applied from the groin to the toes. Where considerable resistance is anticipated, a hip spica will serve to fix the thigh more firmly. A light, well-molded cast will favor weight-bearing early in the treatment. To minimize the resistance sometimes offered by the gastrocnemius, the foot may be fixed in equinus.

When the plaster has hardened sufficiently, it is divided all around the knee, leaving a tongue from the thigh portion snugly over the patella to insure a more even distribution of pressure over this area. In those cases where the subluxation and external rotation are negligible, the hinges and turnbuckles are incorporated into the two parts of the cast with the center of the hinges and the knee coinciding (center of the femoral condyles). Correction is exercised only within the tolerance of the patient, who in many instances soon learns to continue independently at home. Weight-bearing is encouraged just as soon as the plaster is hard enough, either with crutches, or in the gymnasium with the further aid of apparatus.

Retentive braces are worn for at least six months following correction to prevent recurrence of the contracture. In many cases the joints are insufficient to bear weight without support, because of the underlying joint pathology. An existing flexion contracture of the hip will be a factor in causing a recurrence, and must be corrected also. The same holds true for marked gastrocnemius weakness. In both situations locomotion induces a flexion position of the knee in order to satisfy gravital stresses. In some arthrogenic cases there remains a slight residual flexion deformity. This may be finally overcome by applying short skis to the shoes. This will allow the center of weight to be displaced forward, in the upright position, which will exert a correcting stretch upon the posterior structures of the knee.

There are those who offer the following objections to this method: decubitus ulcers, joint stiffness, atrophy, reactivation of the joint pathology, and vascular and nervous disturbances.

Pressure complications can all be avoided by careful application of the cast. Immediate examination of the part causing complaint may

prevent disappointment and alleviate suffering. It may be axiomatically stated that a definite decubitus is already present when the patient complains of actual pain. In our series these were rare and superficial.

Joint stiffness and some limitation of motion is usually primarily present in the arthrogenic type. The postcorrective range of motion will depend upon the degree of joint destruction underlying the disability. Cast stiffness is minimized by having the patient execute the turnbuckle excursion daily. In the pure myostatic cases there should be no limitation of the joint motion, because the recovery of the normal length of the muscle fiber is effective and physiological by this method.

Muscular atrophy is also a usual accompaniment of arthrogenic contractures, and may be a factor in lessened resistance to correction. Daily active tension of the quadriceps and weight-bearing do much to prevent progressive wasting. The duration of the cast period must be considered, and, in some instances, may be prolonged enough to warrant caution in this respect. The method of gradual correction gives the stretched extensors of the knee an opportunity to regain their normal tone. It has been observed that active insufficiency of the quadriceps has resulted from sudden correction, in several cases.

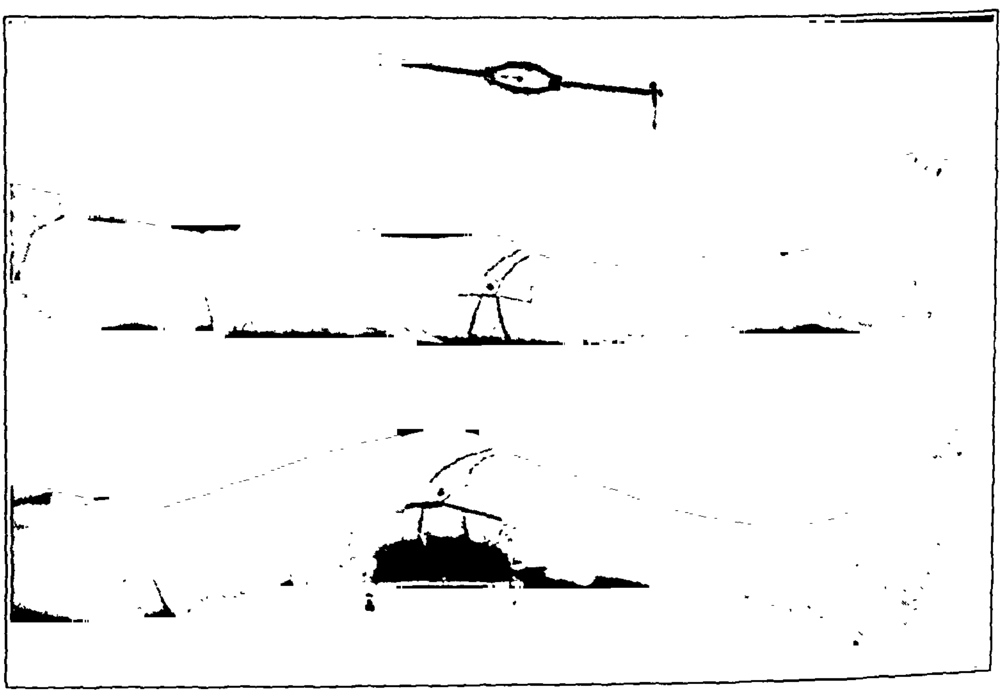

FIG. 2

The upper figure shows the regular type of turnbuckle cast employed for obtaining the initial correction. In the great majority of cases full correction is obtained in this manner. The only changes that are required concern the reapplication of the turnbuckles after their full excursion range has been reached. It is seldom necessary to change the original cast.

The lower figure represents the Quengel method, which is used in those cases offering considerable resistance to the terminal stages of correction.

Following complete correction, posterior plaster splints are applied until the braces are fitted; in the meantime, the patient is ambulatory, and receives physiotherapy.

Reactivation of the joint pathology is seldom noted in properly selected cases. Its occurrence suggests that the joint was unsound at the outset of treatment. It is our custom to apply balanced traction to all cases exhibiting signs of activity, as a preliminary measure. Balanced traction will not in itself correct an actual contracture, but serves to overcome the muscle spasm due to some activity of the joint pathology.

Vascular and nervous disturbances were not observed in this series. Because there have been some definite reports of this in the literature, it is well to bear this possibility in mind. This complication should be feared much more in all the sudden corrective procedures. In those severe contractures that required operation it was never possible to obtain the full correction at once, due to the tension exhibited by the external popliteal nerve, which may also be taken as the index of the vascular tension. These were all finally corrected by the effective application of a turnbuckle cast.

CLINICAL DISCUSSION

Fifty-five cases have been treated by the turnbuckle-cast method, which includes fully seventy-seven knee contractures. There were twenty-three male and thirty-two female patients, in forty-six of whom the contractures were completely corrected. The average duration of the contracture was two and twenty-nine hundredths years, which is taken from the patients' statements, and must be considered with reservations; the actual time was in all probability less. The average time required to obtain full correction was thirteen and ninety-eight hundredths days. The average amount of contracture was thirty and forty-seven hundredths degrees. It is regrettable that the amount of deformity in the secondary planes was not recorded beyond a confirmation of their presence.

The arthrogenic group includes eighty per cent. of the total number. Twelve of these were over fifty years of age, and were in very poor general condition. Sixteen were total invalids at the beginning of treatment, and twenty exhibited multiple deformities. Most of them are now ambulatory, with or without some degree of mechanical support. In the great majority of those who had good motion before treatment, functional activity followed the removal of the casts.

Eight cases were not corrected. Three of these are still under treatment. Three had definite capsular shrinkage, one of which came to operation. This was a contracture of five years' duration incident to an osteomyelitis of the upper end of the tibia. The flexion was overcome from 100 degrees to 150 degrees after persistent turnbuckle correction. The posterior capsule was then stripped according to the technique of Wilson, and was found to be greatly thickened and even adherent to the posterior crucial ligament. Correction progressed to 165 degrees, the tension of the external popliteal nerve prohibiting further extension. When the wound was healed, a turnbuckle cast was effectively applied. It was then found that the old lesion had become reactivated, which

necessitated drainage through an opening in a long leg cast, by the Orr method; this method maintained the corrected position. It is the opinion of the writer that the operative interference which necessitated exposure of the posterior part of the joint was the causal factor in the reactivation of the old osteomyelitic process.

An intercurrent infection interrupted the treatment in one case. In another a metastatic suppurative process, secondary to a boil on the neck, necessitated Orr drainage of the contracted joint. Thanks to this method of drainage, the amount of correction thus far obtained has not been lost, and a functional position of the knee has been retained.

In connection with the arthrogenic types of contracture, it may be stated that actual intra-articular adhesions are a rare occurrence. This has been impressed upon the writer by Dr. Steindler. Of the many knee joints that have been explored, relatively few have exhibited definite fibrous adhesions. This condition as a contra-indication to gradual correction has, therefore, been grossly overestimated.

Twelve of the earlier cases in the series were treated while some signs of joint activity were still present, without complications other than moderate discomfort. There were seven superficial heel and patellar ulcers that responded readily to treatment. Active foci of infection must be taken care of. In one case the presence of an infected unguis incarnatis caused joint pain, which ceased after the local infection was removed surgically.

The arthrogenic contracture, clinically, increases its resistance as

TABLE I

Classification	*Total number of cases*	*Total corrected*	*Average duration of contracture in years*	*Average amount of contracture in degrees*	*Average duration of treatment in days*
1. Arthrogenic:					
Chronic arthritis	27	24	4.40	41.80	29.30
Suppurative arthritis..	4	3	2.80	39.00	13.50
Traumatic arthritis ...	5	4	0.33	43.70	23.00
Gonorrhoeal arthritis..	8	5	0.52	35.00	17.40
	44	36	3.47	39.87	20.95
2. Paralytic.............	5	5	1.00	30.00	14.00
3. Hypertonic...........	3	3	0.34	37.50	14.00
4. Congenital...........	2	1	6.00	30.00	?
5. Postural.............	1	1	0.66	15.00	7.00
	55	46	2.29	30.47	13.98

Clinical analysis of fifty-five cases of flexion contracture of the knee joint, which includes seventy-seven contractures, treated in this clinic by the turnbuckle-cast method of gradual correction. The low, apparent incidence of capsular shrinkage is strikingly borne out by the fact that, of four cases due to suppuration of the knee, three were successfully corrected by this method. The gonorrhoeal group is also remarkable in this respect.

correction progresses. This is especially true in all types of contracture after actual shrinkage has occurred.

The opposite obtains for the hypertonic type of contractures. The initial resistance is the greatest, but when that is overcome, it soon yields to complete correction. The tendency to recurrence is inherent in the spastic contracture. Theoretically, because spastic contractures are labile, they may, under favorable conditions, be induced to reverse themselves. In the upper extremity the condition of "spasmus mobilis" is not uncommon, and has been observed in this clinic. Spastic extension contracture is rare in the lower extremity, but is always induced experimentally in the laboratory by the use of tetanus toxin. It is to the latter investigations that we owe most of our knowledge concerning contracture of muscles. Several hypertonic cases that have been corrected are being retained in extension in casts, in the hope that reversibility, in some degree, may be obtained. It should be remembered, in this connection, that while the genesis of contracture is dependent upon the higher centers and the integrity of the local reflex arc, it is entirely independent after actual contracture has taken place.

Congenital knee contracture can be corrected if attacked early. A case that could not be corrected by gradual extension is of particular interest. This boy presented bilateral marked spastic contractures incident to an extensive spina bifida occulta of the lower dorsal spine. Conservative treatment begun about ten years after birth was ineffective. The child had never walked, and both knees were in 140 degrees of extension at the time of operation. A posterior capsuloplasty, combined with tenotomy and lengthening of the tensor fasciae femoris and all the hamstrings, resulted in 160 degrees of extension. Here again the turnbuckle cast was effective in completely correcting the remaining deformity in about three weeks.

The postural and the paralytic types may be considered together. The results of treatment by gradual correction were excellent. Due to the unopposed action of the tensor fasciae femoris, which so frequently escapes paralysis, the paralytic type of knee contracture is usually remarkable for the degree of valgus and external rotation, which, in extreme cases, may require additional osteotomy. In this group it is especially important to correct all associated deformities and deficiencies, in order to prevent recurrence. The presence of strong glutei and gastrocnemius will exert an extensor thrust upon the knee during locomotion. In recumbency the latter may favor flexion and recurrence.

CONCLUSIONS

Flexion contracture of the knee follows definite physical laws, which apply to all muscular contractures, and is modified by its peculiar anatomical construction.

Gradual correction by the turnbuckle-cast method is offered as the method of choice, in the great majority of cases, because it has proved to

be actually effective in a series of cases, including seventy-seven flexion contractures of the knee joint treated in this clinic. It provides a rigid system, which is so essential for the application of a correcting force upon the largest joint in the body. It may be universally applied, and does not require the construction of special apparatus. It is a method that is urged as a primary procedure, but its further utility preliminary or secondary to operative measures should not be overlooked. Its early application is especially indicated in contractures following actual involvement of the joint, before capsular shrinkage has occurred. As a preventive means, turnbuckles may be incorporated into every cast applied upon a pathologically flexed knee, in order to encourage correction just as soon as activity subsides. In this way even cases of tuberculosis of the knee may be given a better functional position.

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INTERMITTENT HYDRARTHROSIS

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Intermittent hydrarthrosis is a rare affection of the joints in which the periodic swelling is the most characteristic feature. It has been described by several authors under such synonyms as quiet effusion, intermittent hydrops, intermittent synovitis, recurrent synovitis, and hydrops intermittens articulorum.

Moore, in 1864, was the first to identify the condition, although one or two papers which preceded his quoted cases of obviously the same syndrome. As these papers and case reports which followed the original identification are studied, one can see a gradual accumulation of facts which help to complete the picture; yet there is still considerable speculation as to the cause and treatment. Moore's first case followed an attack of ague and was marked further by a remission, beginning with the third month of pregnancy and continuing up to the third month of lactation, when the periodic effusion returned in its former vigor. The case was treated unsuccessfully with various medications, among them arsenic. Arsenic in one form or another has been used, up to and including cases reported by Brackett in 1901 and Marsh in 1905. There is, however, no unqualified approval of its use or that of other medications. Such cases have been treated with quinin and its derivatives, and earlier reports naturally suggested a relationship to malaria. However, this has not been demonstrated. Brackett states that malaria might have something to do with a liability to the disease. He also says that a vasomotor neurosis is the most accepted theory of the causation. In many instances the literature suggests a relationship to angioneurotic oedema. Hildebrand pointed to "the intimate anatomic relationship of the extensive circulation of the knee joint and the nervous system, permitting the assumption that transitory influences acting through either might produce the syndrome". It may seem that the knee joint is an important consideration, for, according to Bierring, it is affected in every reported case.

Schlesinger noted a similarity to angioneurotic oedema and in a recent report presented observations on the occurrence of hydrarthrosis in five members of a family, two of whom also suffered from oedema of the mucous membrane of the mouth, and one from asthma.

Naturally such an assumption brings up the question of hypersensitivity, a feature in the report of Miller and Lewin. On this basis they tried to desensitize a patient with an injection of peptone. This was followed promptly by a marked urticaria, from which it was concluded that the patient was hypersensitive. Subsequent treatment by intra-

venous injections of dead typhoid bacilli rendered the attacks milder in character, and, according to reports some six months later, there was a complete cessation. The fact that remissions characterize this disease offers a difficulty in qualifying any reported clinical cure. Certain points of similarity to Lewin's case will be shown later in this article. Miller and Lewin state that it is open to question whether the results quoted were due to a non-specific desensitization or merely the effect of a foreign protein injection. In this connection, one must also recall the cessation of attacks cited in the first report by Moore during the course of pregnancy.

Two types of intermittent hydrarthrosis are generally recognized, which in current medical usage may be termed idiopathic and symptomatic. The first is described by Lovett, and also by Whitman, as a painless intermittent synovitis occurring usually in young adult females, and is probably related to menstrual irregularities, whereas the second, or symptomatic type, seems to be definitely associated with arthritis deformans.

For instance, Pemberton, in discussing Bierring's paper, states that he believes the condition to be part of the arthritic syndrome at large. In 1921 Bierring reported a case and published with it a complete bibliography containing the known seventy-six cases which preceded his. This survey brought out certain features. In all the reported cases one or both knee joints were involved. The incident was equally divided between the sexes, and pregnancy brought a remission of symptoms during its course. The longest interval was thirty days, the shortest two days. He, as other authors, calls attention to the occasional long remissions.

Bierring suggests that the circulation may be involved, and he feels that there is a strong tendency to associate the phenomena with vasomotor disorders even though many cases have arthritis in the background. The consensus of opinion seems to be that this is a vasomotor disorder, and as such it must presume the question of hypersensitivity.

The presentation of this case report is in its entirety, because of the detailed study of an unusual condition and because the many interesting features which developed seemed to justify it. The patient, a Scotchman and a physician, has so aptly described his plight that it may well serve as a text. The following is quoted from his own statement:

"Toward the end of the year 1917, when aged thirty-three, and while serving with the British troops in France and Flanders, I awakened to the fact that my right knee was subject to attacks of swelling, accompanied by pain from time to time. I accordingly determined to keep the joint under observation and by recording the dates of these periodic swellings found that the attacks were occurring every twelve days.

"Knowing an attack to be due on a certain day, I soon became expert at detecting almost the exact minute of the onset, especially if the onset occurred during walking. I would suddenly experience a slight stiffness of the joint and realize that my strides had become a little bit shorter. Once begun, the stiffness would gradually increase, the knee

swell, and, since the attacks varied somewhat in severity, pain would be present with impairment of mobility in proportion to the extent of the swelling; the swelling would be manifest within about two hours, and by the end of the first day the patella would be floating. The distention would attain its maximum at the end of two days, and within a half hour of its commencing to recede relief would be obtained. By the end of the third day the joint was again normal and no inconvenience felt until the commencement of the next attack.

"The knee was never red nor hot during an attack, nor was there any elevation of temperature. I have, however, on occasion during a severe attack, shivered and felt cold for about an hour preceding the subsiding of the swelling, but my temperature remained unaffected. The periodicity and severity of the attacks were uninfluenced by my daily routine, the seizures arriving invariably time to time, irrespective of the amount of rest or exercise taken between the quiescent periods of the disease.

"At the beginning of the year 1919 my left knee became similarly involved, the seizures, though always of less severity, recurring every twelve days and persisting for three, but alternating with those of the right. Only on perhaps two or three occasions during almost nine years have both knees been affected simultaneously."

In 1921 the patient contracted pneumonia, and following that illness there was a complete remission of symptoms for four months. During the year 1922 the intervals became shorter, and at the end of the year the cycle was a ten-day one. The interval was further curtailed during October, 1923, to nine days. In the early days of the malady the knees returned to normal size, but as time went on a chronic swelling had developed, which never receded, and normal range of motion was lost.

In September, 1923, pain developed in the lumbar spine, which has never completely left. The patient has also noted an increasing loss of mobility in the entire spine.

After a consultation in London, in 1924, the lower teeth were removed and a vaccine prepared from the roots. This was injected intramuscularly, and the patient took calcium and parathyroid extract by mouth. This treatment ameliorated the symptoms to a marked degree, so that the attacks became less severe, the periodicity was upset, and there was a total remission for one month (September, 1924). The following course was marked by a gradual return, until in March, 1926, the attacks were again occurring at nine-day intervals and lasting three. The spine and knees presented an increased swelling, pain, and disability. The patient noticed, however, that the attacks in the knees were never as severe after the vaccine treatments.

The patient was admitted to the Evanston Hospital on September 17, 1927, being forty-three years old at that time. Apart from childhood diseases the patient had had no other illnesses except a Neisser infection in 1906. This was followed within a short time by an acute gonorrhoeal rheumatism. The left knee and the right ankle were affected chiefly, and the patient was confined to bed for eight weeks. A complete recovery ensued, without any evidence of joint impairment.

Physical Examination

The doctor was a man weighing about 170 pounds and walking with the aid of a cane; both knees were flexed; and there was a definite forward stooping at the hips. There was also present a round-shoulder deformity. Motions were performed carefully and any extreme was painful. The head and neck were held rigidly, and the cervical spine was obviously stiff.

Head: Eyes reacted normally; vision was good. The antra transilluminated well and uniformly. The tonsils were of fair size, sclerotic, and considerable caseous pus was expressed on deep pressure. Anterior pillars were red and thickened. Patient wore upper and lower dentures.

Neck: Neck was held rigidly, thrust forward, and motions were limited and painful in all directions.

Chest: Well formed; expansion fair. There was no apparent [illegible] of the ribs. Lungs were clear to auscultation and percussion. Heart was not enlarged; [illegible]

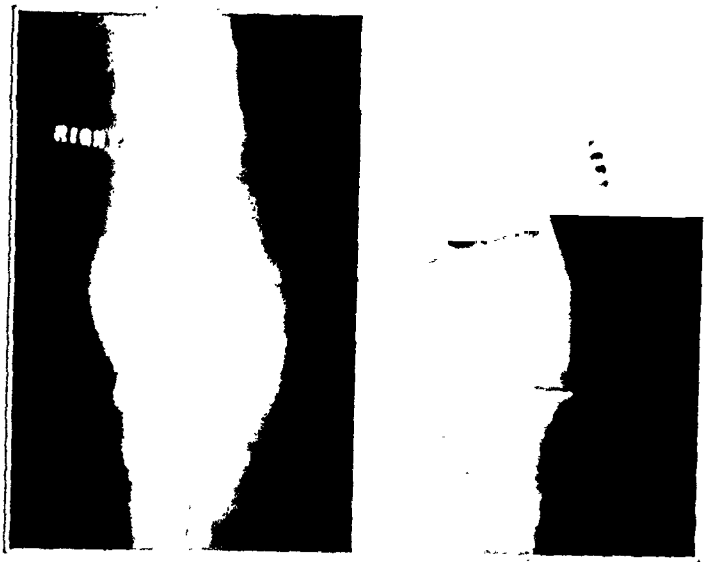

FIG. 1

Roentgenogram of both knees in the anterior-posterior positions, showing the characteristic changes of an advanced osteo-arthritis.

FIG. 2

Roentgenogram of the right knee joint, lateral view, showing lipping of the joint margins, marked diminution in the joint space, and changes in the contour of the joint.

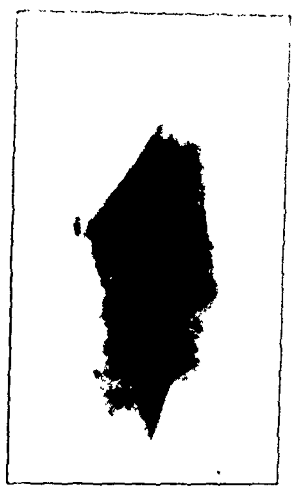

FIG. 3

Lateral view of the left knee joint.

Pulse was soft, regular, and smooth; heart action low in power; capillary circulation poor.

Pulse 80. Respiration 18. Blood pressure 100/66.

Temperature varied during hospital course, but the average was about 98 degrees.

Back: Lumbar spine was flat; dorsal curve was accentuated. Motions were definitely limited in all directions and painful if forced. Deep pressure along spine was painful, especially along the lumbar spine.

Abdomen: Soft. No muscular tone. Pendulous, with rather large fatty panniculus. Intestinal musculature of poor tone. Liver enlarged moderately. No masses or tenderness. Sensitive on deep pressure over spine anteriorly.

Genito-urinary: Prostatic massage revealed a number of pus cells.

Joints: No departure from normal except the above described spine and the knees.

Right knee: Diffusely swollen, obscuring bony landmarks and outlining clearly the quadriceps pouch. The increase was also apparent in popliteal space. The swelling did not fluctuate but was felt as a soft, boggy mass of tissue surrounding the joint. No extremely sensitive areas. The knee was held in from fifteen to twenty degrees' flexion. Flexion was limited to right angles and motion beyond this point or to complete extension was exquisitely painful. During the period of attack the joint became even more swollen and painful and was characterized by a tenseness which offered definite resistance to pressure in contrast to the previous soft pultaceous swelling; it did not pit, however. The superficial veins were dilated.

Left knee: Relatively the same, but much less in degree; motion was of greater extent and the deformity less marked.

Laboratory Examination

Urinalysis: Acid; specific gravity varied from 1.008 to 1.022; faint traces of albumin uniformly present; sugar negative; indican negative.

FIG. 4

A synovial membrane showing hypertrophy of surface cells, a narrow oedematous subsynovial zone and infiltration of deeper tissues with round cells. (16 millimeters' objective.)

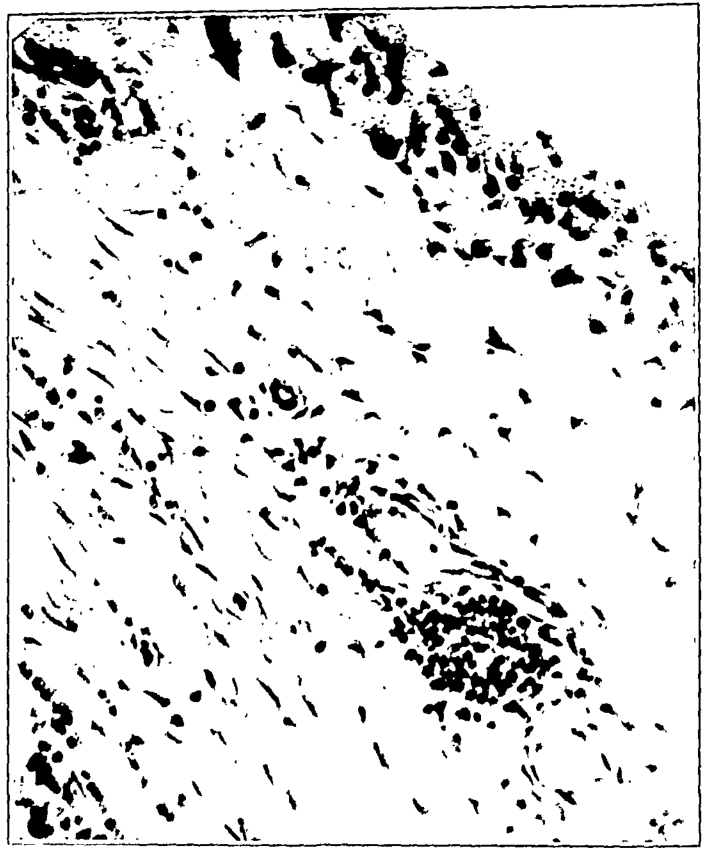

FIG. 5

Synovial membrane with oedematous subsynovial tissue and small nodules of round cells. (8 millimeters' objective.)

Microscopic: Epithelial cells and leucocytes, with occasional few red blood cells and hyaline casts.

Urine culture: Catheterized specimen negative.

Blood chemistry: Urea nitrogen 9.45 milligrams per 100 cubic centimeters of blood; non-protein nitrogen 29.58 milligrams; uric acid 2.78 milligrams; creatinin 1.39 milligrams.

Blood count: Hemoglobin 83 per cent.; red blood cells 4,650,000; white blood cells 6,900.

Basal metabolism: Plus 14.

X-ray Examination

Spine: The lumbar spine showed very definite arthritic changes. In the lateral view the articulating surfaces were roughened and irregular, the lime salts were increased, and the anterior edges of the vertebrae were marked by new bone production.

Knees: In the knees, the intra-articular spaces were quite narrowed; the crucial spines were irregular. The latter were hypertrophied, increased in length, and ended in sharp apices. Both the condyles and tuberosities were squared and sharpened at the lateral margins, and nearly apposed one another. Throughout the bone ends the increase in lime salts was notable. Lateral views accentuated the uneven articulating surfaces and the new bone production.

Pyelogram after cystoscopy: not abnormal.

Course

After entering the hospital the included examinations were made and the patient was kept in bed, with hot fomentations on the knees and traction on each leg. Four days after admission, the tonsils were removed. Three weeks later we could see little change in the local conditions, but did have an opportunity to witness several cycles of periodic swelling in the two knees.

A synovectomy was then performed on the right knee. The operation and convalescence were uneventful. The wound healed promptly, and massage, with passive motion, was instituted within ten days. Following this operation there was a prompt remission of the periodic swelling in both knees. There was a marked effusion in the knee after the operation; but as time passed this gradually subsided, leaving a joint perceptibly improved, both as regards function and symptoms. Up to the present time, a period of two years, there has been no recurrence of the periodic effusion. However, about two months after the synovectomy the patient called attention to vague discomfort in the left knee, and nine days later the knee became swollen and painful. It was evident that the periodicity had again returned in full force to this joint. Two and one-half months after the right knee was operated upon a synovectomy was done on the left knee. The postoperative effusion was more slowly absorbed than in the first instance, but the joint returned to a more normal course. The improvement noted in the right knee failed to appear with the same rapidity, but there was a prompt remission of the periodic swelling which has not reappeared up to the present.

Gross Pathology

Upon incising the thickened capsule of the right knee joint, purplish red clusters of synovial membrane popped into the wound. A careful dissection was made, removing in all about two handfuls of the synovial tissue which covered and obscured any view of the joint. The hypertrophied fringes extended well up and completely filled the quadriceps pouch. The crucial ligaments were covered and a mass was reflected about the infrapatellar fat pad. Scattered through the synovial fringes were large globules, about one inch square and perhaps one-quarter inch in thickness. The globules were of a pale cream color and in most instances attached to the membrane by a very fine pedicle; they were probably masses of fibrin.

The cartilage of the tibia and condyles had lost the natural luster, was quite thin, and contained irregularly roughened areas of a distinctly yellow cast. At the extreme marginal attachments the cartilage was definitely eroded by a pannus. This was particu-

FIG. 6

Synovial membrane with large nodules of round cells and several sclerotic vessels. At the upper right corner there is a bit of fibrin, which is adherent to a neighboring villus. *(16 millimeters' objective.)*

larly well shown in the intercondyloid notch, where the most serious invasion and erosion had taken place. The synovial fluid was small in amount and distinctly yellowish in color.

The left knee presented practically the same picture. However, the amount of hypertrophied synovial tissue was much less, though even here considerable erosion of bone and cartilage had taken place along the joint margin.

Gross Examination

"Specimen consists of four large and several small fragments of soft tissue. For the most part the consistency is that of fat, with relatively little fibrous tissue. In some places the synovial surface is comparatively smooth, while in others there are a few medium-sized villi. Some of these villi are branched, others are pedunculated. In some areas the synovial membrane is moderately thickened."

Microscopic Examination *

"The synovial cells are moderately increased in number and are from two to four times as large as normal. There are from three to eight layers of these cells, and in some areas the large, elongated, synovial cells are arranged with the long axis perpendicular to the joint surface, with one or more processes projecting into the joint cavity. Many of these large cells contain from two to four nuclei. The subsynovial layer is abnormal in that it is markedly oedematous and is moderately infiltrated with [illegible] cells. Beneath this oedematous layer there is in places a thick layer of adipose tissue. It

* The authors are indebted to J. Albert Key, M.D., of St. Louis, for the microscopic analyses and the photomicrographs.

some places the oedematous tissue contains a thin coagulum which is probably fibrin. In other places the oedematous subsynovial layer rests upon a layer of fibrous tissue which is about normal in thickness and consistency. The infiltration of the subsynovial layer with mononuclear cells is in places quite marked and takes the form of collections of small round cells three or four hundred microns in diameter. As a rule the infiltrating cells are medium-sized round cells of the type usually described as monocytes or endothelial leucocytes. There are also a few phagocytic cells which are loaded with broken-down red cells (elasmatocytes). In some sections these are very numerous. Some of the monocytes contain several nuclei and resemble foreign-body giant cells. Some sections contain hyalinized areas which are sparsely populated with fibroblasts, small round cells, and extravasated red blood cells.

"A hyaline layer may replace the subsynovial oedematous layer. This hyaline layer is apparently fibrin which has become adherent to the synovial surface and invaded by connective-tissue cells and blood vessels. The villi are of various sizes and shapes, ranging from small sessile villi to large pedunculated villi with extensive branching. In structure the villi do not differ materially from that of the synovial surface described above.

"The vascularity of the tissue varies greatly in different sections. The hyalinized and oedematous areas contain relatively few blood vessels, while many of the villi are richly supplied. The walls of many of the smaller blood vessels are thickened and many of them are surrounded by a hyalinized zone. On the other hand, some of the large villi contain large, thin-walled, vascular spaces.

"The tissue contains relatively few polymorphonuclear leucocytes. The hypertrophied synovial cells do not contain any visible vacuoles or granules. No large lymph spaces were seen in the section."

Diagnosis: Chronic arthritis.

Discussion: The specimens from the two knee joints present practically the same picture. The pathological changes resemble those found in chronic atrophic (proliferative) arthritis. However, the extensive hyalinization and the large amount of oedema present in these joints would be unusual findings in the ordinary atrophic arthritis.

COMMENT

It is nearly five years since the synovectomies were performed, and up to date there has been no recurrence of the periodic effusion. In a recent personal communication the patient states that at the present time he is completely bed-ridden by the progressive arthritis, which has involved the spine and hip joints to a severe degree.

This case obviously falls within the group reported as having a close relationship to chronic arthritis. The remission, which occurred following pneumonia and again when an autogenous vaccine was given, is of interest. Throughout the literature it has been noted that pregnancies have provided periods of remission. In a personal communication (Shands and Leadbetter) was given the report of a case of intermittent hydrarthrosis which was completely interrupted by pregnancy. Shands also described a case in which streptococcus viridans was cultured from fluid aspirated from the affected joint. When an autogenous vaccine was given, the condition was much improved. This patient also had an associated arthritis.

The authors feel that this process falls within the scope of an allergic reaction, and the case history reported seems to bear out this assumption; however, no adequate explanation of the periodicity is at hand.

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FRACTURE OF THE PATELLA

A New Operation

BY FRANK R. OBER, M.D., BOSTON, MASSACHUSETTS

During the past decade the use of living sutures in cases of fractured patellae has become increasingly popular among surgeons. Strips of fascia lata or tendons are used for this purpose. When such strips are used, two incisions are necessary,—one to expose the patella, and one to expose the structures from which the suture material is to be obtained. In the operation described below, only one incision is necessary.

The incision is started four or five inches above the patella in the mid-line of the thigh and, as it approaches the patella, is swung medially to it, curving backward to the ligamentum patellae. The tendon of the quadriceps extensor, the aponeurosis of the patella, and the upper third of the ligamentum patellae are exposed. From the quadriceps tendon, which is very thick, there is split off transversely from above downward to the superior border of the patella a four-inch flap, the lower end of which is not divided. This flap is now split longitudinally, giving two strong strands of tendon about one-quarter of an inch wide. The patella is next

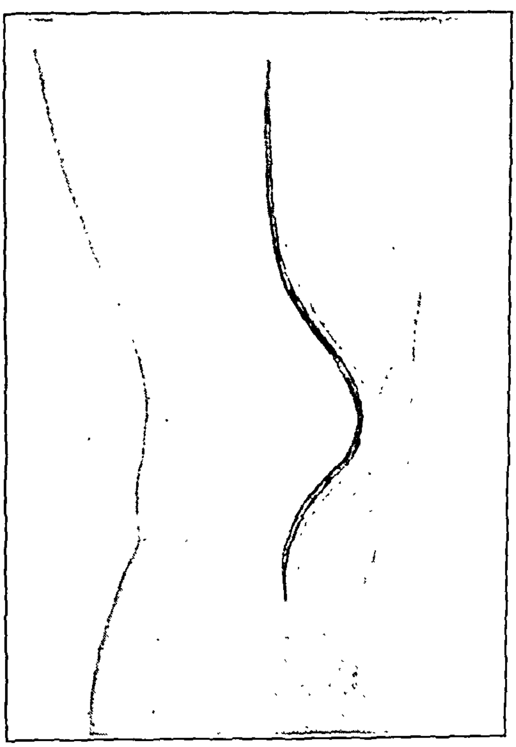

FIG. 1
Skin incision.

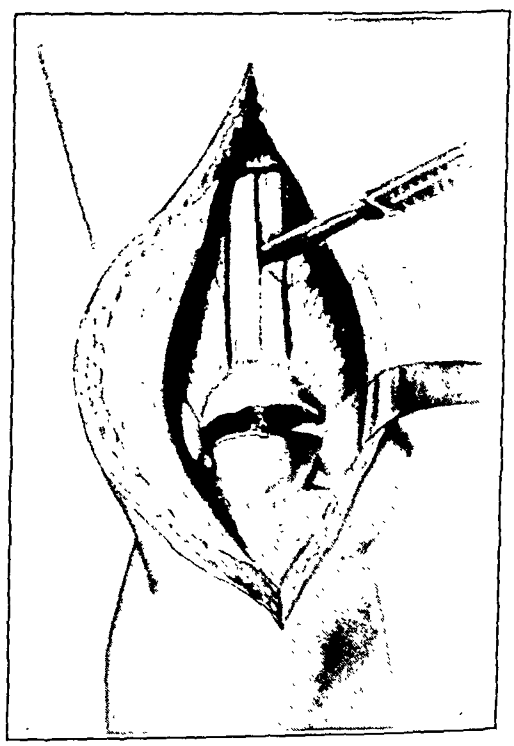

FIG. 2
Quadriceps tendon exposed, showing strips being dissected off anterior half of the tendon.

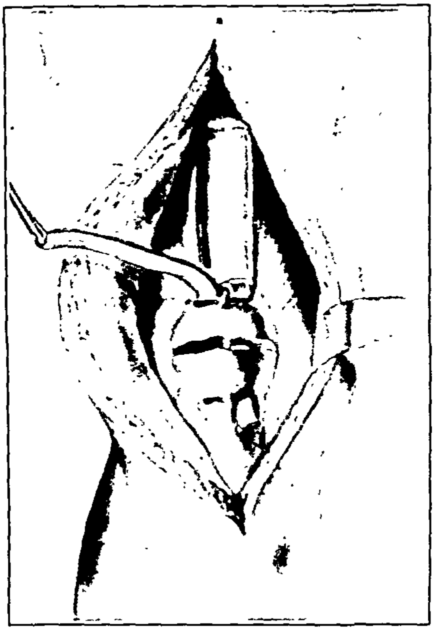

FIG. 3

Showing free strips of tendon left intact at lower ends, longitudinal drill holes in the patella and one tendon strip passed through drill hole.

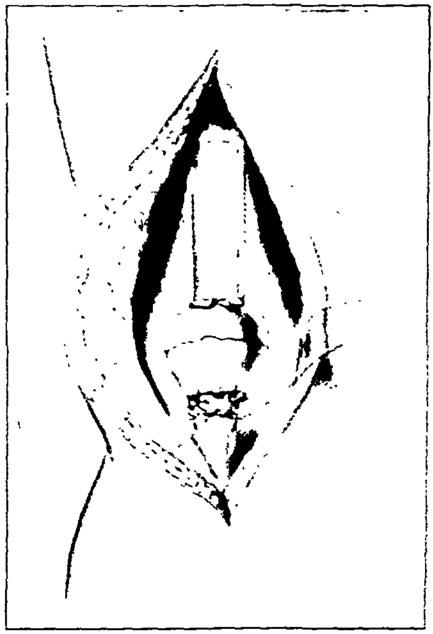

FIG. 4

Showing two tendon strips drawn through the drill holes and sutured to each other and also to the ligamentum patellae.

drilled from above downward with a quarter-inch drill medial and lateral to each strand. A tendon strip is now passed through each drill hole. The protruding ends are sutured to each other and to the scarified ligamentum patellae.

REPORT OF CASE

G. W. C., aged sixty-two, Rec. 15741. July 7, 1930.

On June 22, 1930, this patient, while riding in an automobile, was severely injured in a head-on collision. He sustained a transverse fracture of the left patella, a severe cut of his lower lip, and a large scalp wound above the left ear. The patient was taken to the

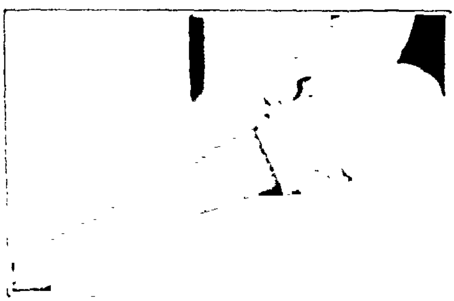

FIG. 5

Knee voluntarily extended

FIG. 6

Knee flexed

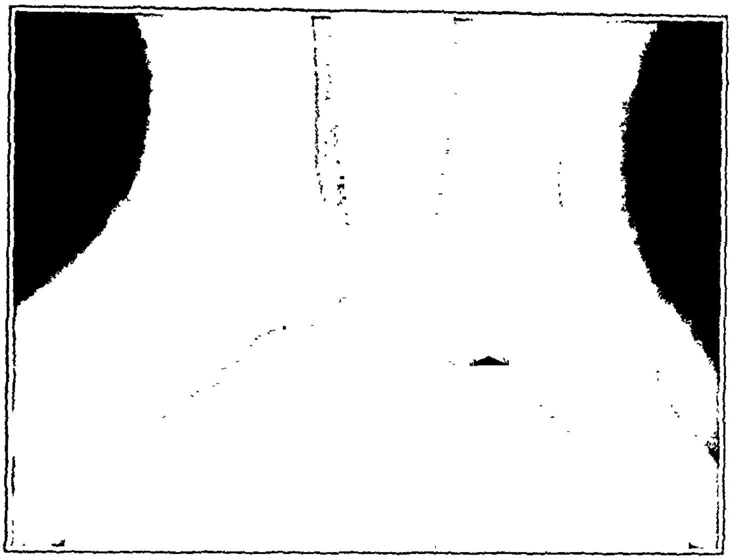

FIG. 7

Lateral x-ray. Shows solid union. Patella enlarged. Exostosis at upper margin does not interfere with function.

Norman Cross Hospital in Three Rivers, Quebec, where he stayed until July 5, when he was transported *to Boston.*

The operation described above was performed under spinal anaesthesia. On exposing the patella, a transverse fracture at the junction of the lower and middle thirds was seen. The fragments were separated about three-quarters of an inch, and the lower fragment was rotated anteriorly at its superior aspect. The knee joint was filled with organized blood clot and serum. The joint was slowly irrigated with normal salt solution, washing out all detritus.

The patella was united as described in the text; the torn capsule was sutured with interrupted chromic catgut No. 0, and the subcutaneous structures with plain catgut No. 0. A plaster cast was applied from the toes to the groin.

September 29, 1930: The cast was removed, and there seemed to be solid union. Patient was allowed to walk on crutches.

October 10, 1930: Thirty degrees of free motion.

November 1, 1930: Back at work, is able to walk without support, and can climb stairs. No pain.

March 25, 1932: Can extend knee completely and can flex it to eighty-five degrees. Solid union. No disability.

"OSTEOPLASTIC CUNEIFORM OSTEOTOMY" IN THE TREATMENT OF ANKYLOSIS

Report of Two Cases

BY S. ORELL, M.D., STYRSÖ, SWEDEN

From Styrsö Coast Hospital, Gothenburg, Sweden

For the past few years I have been investigating the use of small bone grafts implanted in the wound of the tibia at the site from which is generally taken the piece of bone used at the so called Albee operation in the treatment of spondylitis. In so doing I have found that boiled autoplastic bone grafts, implanted subperiosteally into defects of the bone, usually behave similarly to fresh bone grafts implanted in similar places.

The results of these investigations have also been used in bone transplantations in practical surgery. The description of two cases treated by this method is presented herewith.

Case 1. K. J. P., woman, aged twenty. (J. Styrsö Coast Hospital, Nos. 4096-5054-6614.) Admitted to Styrsö Coast Hospital February 21, 1930.

Extract from case report: At the age of seven patient had tuberculosis of right knee. Was treated for this complaint at Styrsö Coast Hospital in 1919 with the result that on her discharge the gonitis was healed, with the knee in good position and a mobility of about seventy degrees. According to the patient's statement, after discharge the knee became gradually stiff and crooked. She was readmitted to Styrsö Coast Hospital for recurrence of trouble during 1923-1925, and was subsequently discharged in healed condition with ankylosis of knee in about thirty degrees of flexion.

She was again admitted to the hospital on February 21, 1930, with symptoms of appendicular abscess.

Condition on admission: General condition impaired. Temperature, thirty-nine degrees, centigrade. Nothing abnormal in the chest. Abdomen tense. A large tender swelling could be felt in the right side of the abdomen.

Ankylosis of right knee, quite free from tenderness and not swollen. The knee was in a position of about forty-five degrees of flexion and about thirty degrees of abduction with the thigh.

The muscles of the right leg were considerably atrophied. As a result of the flexion contracture there was marked functional shortening of the right lower extremity, causing the patient to limp considerably. By more exact measurement of thigh and leg, a true shortening of the extremity of three to four centimeters was evident.

Lateral roentgenogram of right knee showed complete ankylosis, bone structure of typical nature and without signs of tuberculous foci. The tuberculous lesion had healed perfectly. There was no swelling of the joint capsule, in bone no signs of [illegible] changes. The patella was lying in front of the femoral condyles, the femur forming an angle of flexion with the tibia of forty-five degrees.

After the appendicular abscess had been drained and the patient had recovered from her severe septic state, I began to ponder upon the best method to correct her right knee.

By a simple cuneiform osteotomy one could, it is true, [illegible]

of the flexion contracture, but at the same time would get a true shortening of the extremity.

Such a shortening could also be obtained by an *arc-shaped cuneiform osteotomy* according to Helferich, or by a *frontal osteotomy* by Schepelmann's method.

An *arc-shaped osteotomy* by Stracker's method would not, on the other hand, result in any shortening. This operation is carried out through a lateral curved incision. The bone is cut through by saw, by the aid of a specially made block, in such a way that a transverse, much curved cylindrical surface is obtained, the axis of which is at right angles to the long axis of the femur. Along this cut surface the bone fragments can then be rotated in relation to one another as in a joint, and the flexed position of the knee can be corrected.

Yet great difficulties are encountered in the practical execution of Stracker's operation. It is difficult to obtain a cut surface with the desired curved shape by sawing through the bone during an operation. It is naturally much easier to cut out plane surfaces by the saw and there is much greater prospect of obtaining the desired result.

I therefore carried out the operation in this case in a method similar to osteoplastic amputations, and which I would like to call "*osteoplastic cuneiform osteotomy*".

On a lateral roentgenogram, taken before the operation, I drew with straight lines the wedge—of an angle of about thirty-five to forty degrees—that would have to be removed in a simple cuneiform osteotomy.

If now, only the upper half of this wedge were removed—that is, a wedge with half the angle—and this wedge were rotated through 180 degrees and then replaced between the intact ends of the bone, one would gain in this way, as well as by Stracker's method, a straight extremity, with no loss of bone and no shortening and, moreover, the bone could be cut through in simple planes.

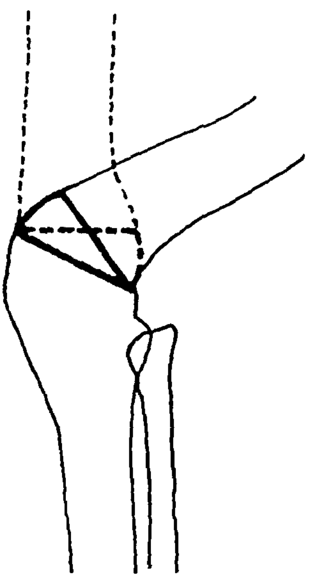

FIG. 1

The thick black contours indicate the cut surfaces of the wedge; the dotted contours indicate the corrected position. (From *Die Technik des Orthopädischen Eingriffs,* by Ph. J. Erlacher. Vienna, Julius Springer, 1928.)

The operation was thus carried out in the following manner on May 9, 1930.

Osteoplastic cuneiform osteotomy:

Curved incision above patella from epicondyle to epicondyle. After cutting through the periosteum, this was detached upward and downward by a rasp. The bone was cut through by a hand-saw at the site of ankylosis so that, of the wedge that would have to be removed in a simple cuneiform osteotomy, only the upper half was removed. The wedge consisted of very brittle, spongious bone, with large cavities filled with fatty marrow and no traces of tuberculous foci. As the wedge during the operation happened to be touched by some unsterile object, it

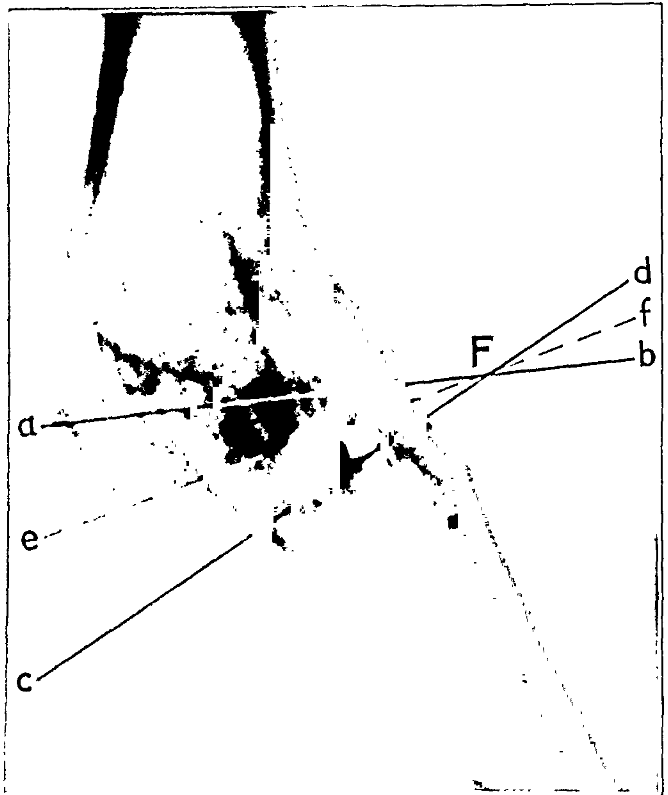

FIG. 2

The straight lines *ab* and *cd* indicate on the roentgenogram the wedge that would have been removed in an ordinary cuneiform osteotomy. *Line ef represents the cut plane through* which the angle of the wedge *aFc* is bisected into angles *aFe* and *cFe*.

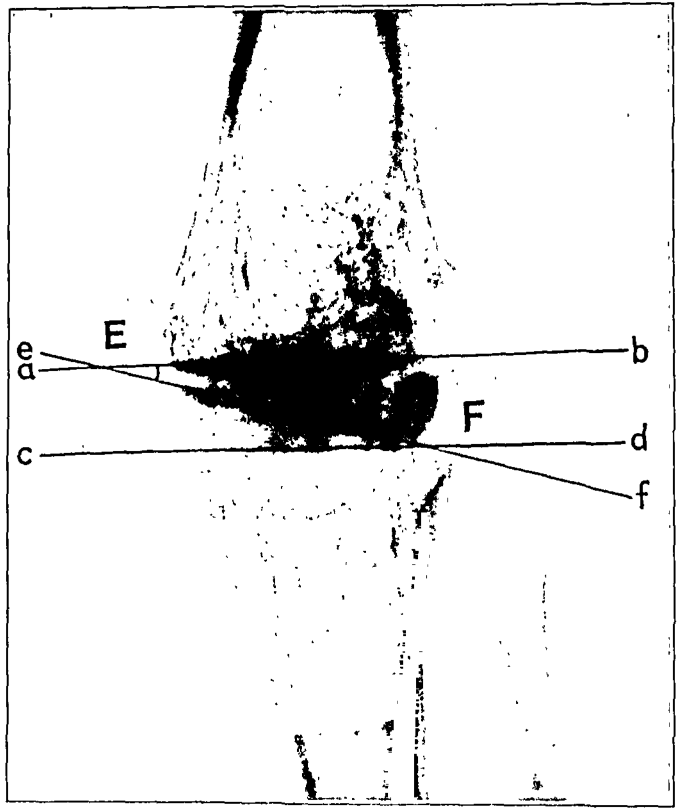

FIG. 3

Roentgenogram showing the position of the wedges after the operation. The upper wedge has at the operation been *rotated* through 180 degrees and the angles of the two wedges, *bEf* and *cFe*, have now such a position in relation to one another that the *extremity* has been straightened out.

was boiled for ten minutes in physiological sodium-chlorid solution. The wedge was rotated about 180 degrees and fitted in between the cut ends of the femur and tibia so that its highest part was placed posteriorly (Fig. 1). In so doing the tension of the soft parts was rather strong but was overcome without any greater difficulties. The position of the bones was thereby perfectly straightened. The wound was closed by primary suture and plaster bandages were applied around thigh, leg, and foot. The extremity was elevated to prevent too great postoperative bleeding. The operation was carried out under ether anaesthesia.*

The method of operation is best understood from the diagram (Fig. 1) and from the lateral roentgenograms, one taken before operation and another afterwards (Figs. 2 and 3), on which the wedges mentioned above will be found marked out by straight lines. On the roentgenogram after the operation, the bone graft will be seen, carefully fitted in between the femoral and tibial fragments.†

* For cutting out the wedge in osteoplastic cuneiform osteotomy I generally make use of a T bevel adjusted by roentgenogram before the operation; this has a convenient locking device which, after locking, prevents the blades from separating (Fig. *a*). Such bevels are adjusted after lateral and anteroposterior roentgenograms have been taken and are locked, after which they, together with the other instruments, are sterilized before operation. For this reason they are made of nickel-plated steel.

If, for the same purpose, one wishes to use a graduated, finer, and more expensive tool, then a Universal bevel protractor (Fig. *b*) may be used.

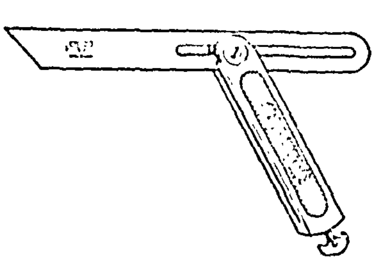

FIG. *a*

T bevel. (*Courtesy of The Stanley Rule & Level Plant, New Britain, Conn.*)

Should a more precise measurement of the height of the estimated wedge be desired, a Vernier caliper or a Fay spring divider (Fig. *c*) may be used with advantage; this is also adjusted after roentgenograms have been taken and is sterilized before operation.

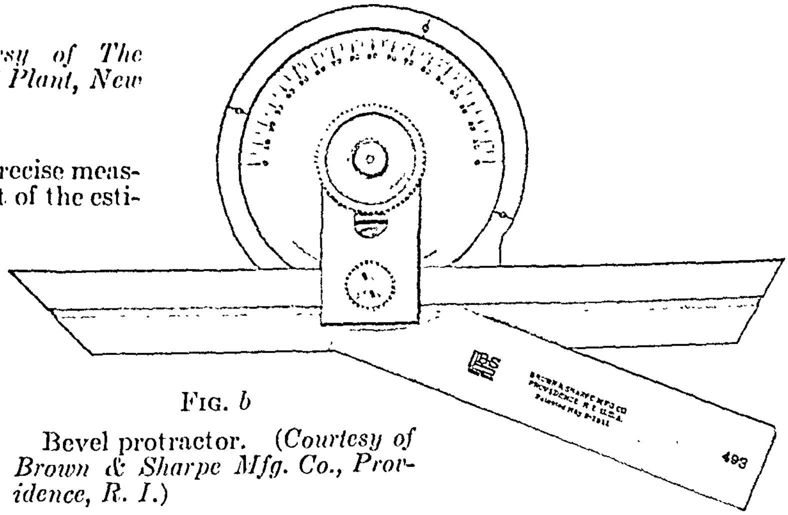

FIG. *b*

Bevel protractor. (*Courtesy of Brown & Sharpe Mfg. Co., Providence, R. I.*)

If during the operation it is wished to mark out on the bone the planes to be cut through by the saw, this is done by scratching with a pocket scriber (Fig. *d*).

It should be pointed out here that these exceedingly cleverly devised and tried tools, which are employed by craftsmen in skilled work with wood and iron, and of which a large assortment is made in standard models by the great tool manufacturing works, should be called into aid in our surgical work.

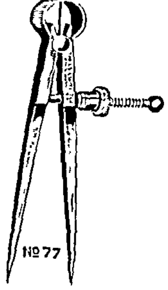

FIG. *c*

Fay spring divider.

FIG. *d*

Pocket scriber.

(*Courtesy of The L. S. Starrett Co., Athol, Mass.*)

† Application of Euclid, I, Proposition XXVII,—If a straight line meeting two other straight lines in the same plane makes a pair of alternate angles equal, then these two straight lines are parallel.

The general condition was satisfactory after the operation, the wound healing by first intention. There were no motor disturbances in the leg.

During the ninth week after the operation the patient was allowed to put weight on her legs with her right leg in plaster. There was no pain in the knee and gradually she became able to walk quite unhampered and without any inconvenience from the knee.

September 14: Patient was discharged four months after the operation. General condition was good, with good position of the knee.

November 31: The knee felt quite firm, as in bone ankylosis.

December 2: Leather support was applied.

On examination in March and August 1931, the knee was still in a good position. The iliac-spine-malleolar line on the right side is now only one and one-half to two centimeters shorter than on the left side. After the operation the extremity would thus seem to have become longer, probably as a result of increased function or strain after correction of the flexed position.

REPORT ON THE ROENTGEN EXAMINATIONS

Anteroposterior and lateral roentgenograms were taken 14, 61, 118, 304, 350, 378, 406, and 465 days after operation.

Roentgenogram 14 days after operation: The structure of the lateral part of the graft is very thin and does not reach the borders of the condyles. The medial part of the graft is also thin and almost devoid of structure. No periosteal or endosteal reaction.

FIG. 4

Case I. Anteroposterior roentgenogram 465 days after the operation.

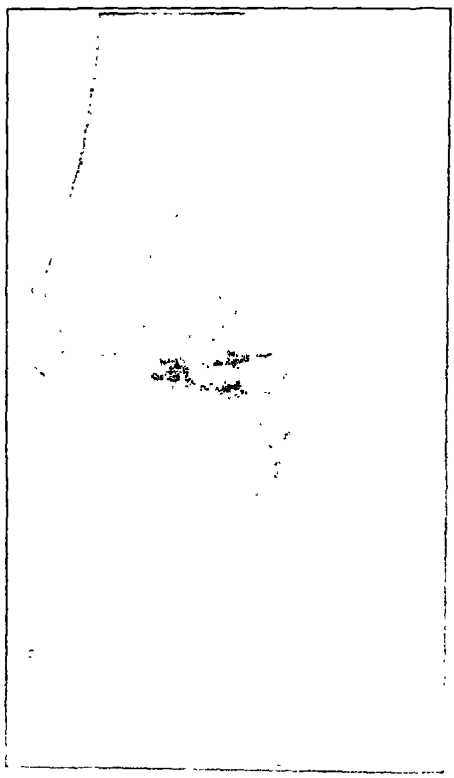

FIG. 5

Case I. Lateral roentgenogram 465 days after the operation.

Roentgenograms 61 days after operation: Graft partly sclerosed. Still no periosteal or endosteal reaction.

Roentgenograms 118 days after operation: The graft appears to be somewhat lower than before, with small absorptive foci.

Roentgenograms 304 days after operation: Graft much more sclerotic than before. Still no periosteal reaction but an unquestioned endosteal reaction.

Roentgenograms 350 days after operation: Increasing endosteal reaction; now there is also definite structure with well marked bone laminae.

Roentgenograms 406 and 465 days after operation: The new bone formation now appears with more distinct structure than before. In addition distinct absorptive foci can be seen in the posterior higher parts of the graft (Figs. 4 and 5).

If the lateral roentgenograms 61 and 465 days after the operation are compared, the grafted wedge on the latter appears to be lower than on the former. It is clear from measurement, however, that the angle between the femur and the tibia is the same and that the condylar regions of the femur and the tibia are of the same height.

CASE 2. S. E. K., male, aged fifteen. (J. Styrsö Coast Hospital, No. 6677.) Admitted to Styrsö Coast Hospital on June 28, 1930.

Extract from case report: Since 1925 patient had been suffering from left-sided tuberculous coxitis for which he had been treated in the hospital since 1926.

On admission to Styrsö Coast Hospital on June 28, 1930, the coxitis was perfectly healed, both on clinical and roentgenological evidence, with bony ankylosis of the hip joint, the femur in about five degrees of abduction and about thirty degrees of flexion in relation to the pelvis, and with about five centimeters of functional shortening of the left leg. Patient was admitted to the hospital for correction of the faulty position in the hip joint.

By measurements it was ascertained that for equalizing the length of the legs one needed an increase in the abduction of the hip of about thirty degrees.

August 14, 1930: Operation: *Subtrochanteric osteoplastic cuneiform osteotomy with replantation of wedge.* With a Gilgi saw a wedge was cut out of the left femur below the trochanter, so that each cut plane formed an angle of fifteen degrees with the transverse plane of the femur. The angle of the wedge was thus thirty degrees and its apex situated medially. The wedge was then boiled in physiological sodium-chlorid solution for at least ten minutes, and afterwards replaced after rotation through 180 degrees in its former position, the apex of the wedge thus pointing laterally. The apex of the wedge was fixed to the intact femoral fragments by strong catgut. By the aid of the extension arms of the operating table the extremity was so adjusted that the femoral fragments formed an abduction angle with one another of thirty degrees, allowing the wedge, as evidenced by roentgenogram, to fit in well between the fragments. The wound was closed and a circular plaster applied around ankle, knee, and hip.

Stitches were removed two weeks after the operation; the wound had healed. On September 12 a great amount of clear brown fluid escaped from the wound at one place as if originating from a hematoma.

September 17: Wound again closed and dry.

November 3: Three months after operation; patient able to dress.

April 10: Leather support recommended. Discharged well in July 1931.

REPORT ON THE ROENTGEN EXAMINATION

Anteroposterior views were taken 27, 56, 84, 113, 151, 193, 256, and 299 days after the operation.

Roentgenogram 27 days after operation (in plaster): The bone graft fits well between the fragments of the femur. The angle between the femoral fragments is thirty degrees. Periosteal reaction is beginning.

Roentgenogram 56 days after operation (in plaster): Absorption is beginning in the graft and in the adjacent bone ends. The periosteal reaction is more prominent than before.

Fig. 6

Case 2. Anteroposterior roentgenogram 27 days after the operation.

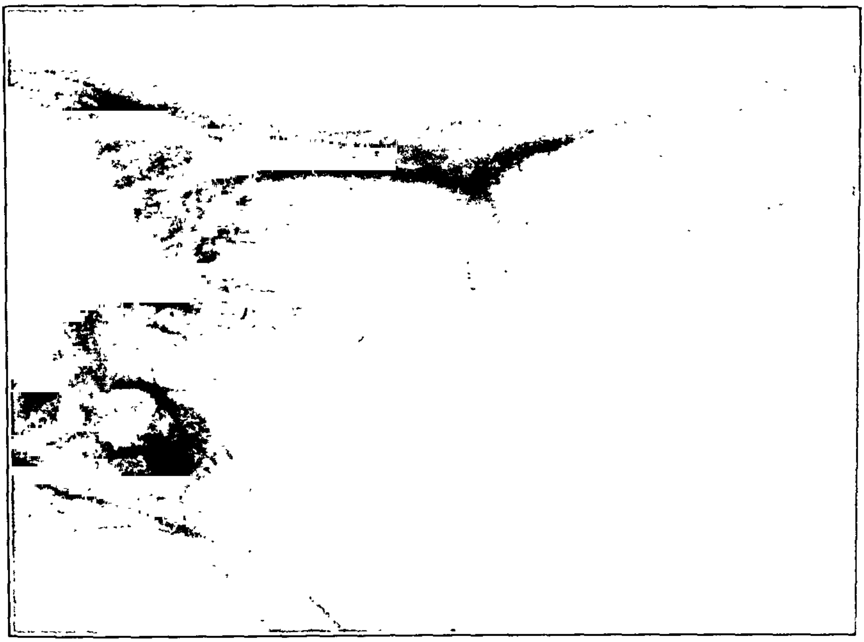

Fig. 7

Case 2. Anteroposterior roentgenogram 299 days after the operation.

Roentgenograms 84, 113, and 151 days after operation (in plaster): Increased tendency to absorption with fragmentation of the graft and about one centimeter of the adjacent ends of the femoral fragments. No collapse of the graft or of the ends of the femoral fragments can be seen, however. At the same time the new bone, periosteally formed, is becoming more and more dense.

Roentgenograms 193, 256, and 299 days after operation: The new periosteal bone is becoming more and more prominent. There is also now an obvious endosteal reaction. The graft can scarcely be discerned any longer. There is no demonstrable shortening of the leg.

The graft appears to have become disintegrated and absorbed as have also the nearest portions of the femoral fragments, while new bone is being formed by the tissues surrounding the graft. The compact bone and marrow of the femoral fragments do not seem to undergo any changes except in their very outermost ends. The new bone seems to arise in those soft parts close to the bone where injury has taken place. The newly formed bone assumes a shape and dimensions, in all probability occasioned by the altered mechanical conditions, resulting from the osteotomy and transplantation.

A characteristic feature of both these cases, and one of particular interest, is that the cut-out and replaced bone wedge could be precisely estimated beforehand, both regarding size and shape, and then cut out accordingly and exactly at the operation and, further, that the bone wedge, although it was boiled for ten minutes in normal saline, became united with the neighboring bone and clinically fulfilled in a perfect manner the desired function.

By osteoplastic cuneiform osteotomy we aim at a reshaping of the bone by resection of a wedge-shaped segment, carefully estimated beforehand, and its replacement or replantation in a different position. The bony wedge will then by its shape and adaptation contribute to the maintenance of the altered shape of the bone after operation. Thanks to the wedge fitting in well between the bone fragments and all cut surfaces being simple planes, no spaces arise between these surfaces; wherefore, the conditions for bony union are rendered as favorable as possible.

In the above described cases of osteoplastic cuneiform osteotomy it is, however, not only the method of operation in itself that is of interest, but also the question as to how the resected and replanted grafts unite after the operation.

My two cases of osteoplastic cuneiform osteotomy, which were carried out under strict observance of the general rules of surgery and asepticism, show a union of the boiled pieces of bone which on the whole tallies well with the results gained by Epstein and Kasakevič as found on examination of the fresh bone segments after experiments with Springer's operation on guinea-pigs.[7]

This is true in the first place of the clinical functional result. My patients began to walk with local support after having been in bed for from two to four months. Twelve months or more after the operation there has still been no clinical nor roentgenological signs of collapse of the bone wedges nor any evidence of their having been unable to cope with the mechanical strain to which they have been exposed during walking. The union between adjacent fragments has been good.

With regard to the dominating part that the periosteum is supposed to play in the regeneration of bone, the two cases here described behaved differently. In Case 2 the roentgenograms show, as after Springer's operation, how new calcified material is being formed in large quantities below the periosteum surrounding the wedge and ends of the bone fragments. In Case 1, however, one is unable to find that the periosteum is of any importance in the osseous regeneration. At the outer borders of the wedge, as in those parts lying close to the periosteum, no new bone formation can be seen but instead a depression of the bony outline. New bone formation, apparent on the roentgenograms as a new formation of bony structure, is only discerned within the substance of the bone wedge, particularly in the lowest parts of the wedge.

As in both my cases the cells of the bone wedge must be considered dead on account of the boiling, the new bone formation must have taken place from the cells of the surrounding living tissues. Which tissues or cells have thus created the new bone can of course only be determined by histological examination.

The roentgen examination in my second case, however, goes to show—like Epstein's and Kasakevič's investigations of guinea-pigs after Springer's operation—that in bone transplantation in the diaphysis the regeneration of bone is of periosteal type; while the roentgen examination in my first case, on the other hand, indicates that in bone transplantation in the epiphysis the bone regeneration is of endosteal type. These two types of bone regeneration remind one of new bone formation of the cartilaginous skeleton during the embryonic stage of development,—that is, of the perichondral and enchondral new bone formation in diaphyses and epiphyses, respectively.

The signs of necrosis and resorption of the bone substance in the wedges or segments and in the ends of the solid bone fragments are obvious in both my cases. Yet the necrotic processes and resorption of the bone do not seem as yet to have resulted in any diminished stability of the bone wedges, or, at any rate, the necrotic parts together with the new bone have exhibited such a mechanical stability as to enable the bone wedges to fulfil their function. The necrotic parts of the bone in the central parts of the wedges remain for a rather long time and will probably gradually be replaced by new bone from the cells of the invading tissues, or possibly become partly absorbed and replaced by connective tissue (Phemister)[24].

A pseudarthrosis may, of course, occur in such cases where the surgical fixation after the operation has been unsatisfactory.

As mentioned in the early part of this paper, I had previously found that small pieces of boiled bone implanted subperiosteally in bone defects behave practically in the same way as small fresh bone fragments in a similar place.

Judging from Epstein's and Kasakevič's writings and according to my own two cases described above, relatively large bits of boiled bone implanted as wedges between cut bone ends also would seem to behave on

the whole in the same way as large pieces of fresh bone implanted as segments in a similar place. The slow resorption of the necrotic parts in fresh and boiled bone and equally slow substitution of new bone is probably due to the difficulties encountered by the surrounding living tissues in invading the interior of the bone sufficiently rapidly, by their newly formed cells. It has thus happened that after homoplastic transplantation of fresh bone grafts of larger size, a shorter or longer time after the transplantation, these have collapsed and been unable to withstand the mechanical strain involved (Lexer and others).

It is clear, then, that when bone is to be transplanted, it should undergo some preliminary preparation in order to facilitate a speedy invasion of tissue juices and cells into the canal systems. This preparation should aim at removing connective tissue and fat as completely as possible from the canals to enable the tissue juices and cells to come in direct and intimate contact with the bone substance of the walls of the canals. In addition, a removal of nitrogenous substances in homoplastic and heteroplastic transplantation of bone is likely to have a more favorable effect upon the bone regeneration than is generally the case otherwise. I have employed such a method of preparation in several cases, which method will be described in a future publication.

The x-rays have been examined and the roentgen reports revised in conference with Dr. Nils Westermark, Physician-in-charge of the Roentgen Department of S:t Göran's Hospital, Stockholm.

SUMMARY

"Osteoplastic cuneiform osteotomy" in ankylosis of the knee joint or hip joint with a position of flexion or adduction has from an operative point of view—besides the maintaining of the true length of the extremity—the technical advantage that the osteoplastic osteotomy, because of the osteotomies being laid in simple planes, can be carried out exactly as estimated beforehand. In consideration of this, the method would seem likely to be of use in other cases of similar nature and perhaps also be useful in plastic treatment of other bone deformities.

Osseous segments can be resected, boiled, and again implanted with a good prospect of union and function.

The union of boiled autoplastic bone segments in bone defects would seem to proceed clinically and roentgenologically in the same manner as the union of fresh autoplastic bone segments. The boiled segments seem, like fresh ones, to be mainly replaced by new bone tissue, while the old bone tissue undergoes necrosis and becomes resorbed. Smaller portions of necrotic bone tissue in the segments are for a long time evident in the roentgenogram. The boiled bone segments seem to be able to fulfil the mechanical function aimed at by the plastic operation.

After resection and reimplantation of segments in the diaphysis, periosteal bone regeneration is the dominating one; after such operations in the epiphysis, endosteal regeneration predominates.

A preliminary preparation of the bone graft for the purpose of removing, as completely as possible, connective tissue and fat from the bony canals would probably, in a grafting operation, hasten and render more complete the union and reconstruction of the graft. The author has worked out such a preliminary therapeutic method and is at present subjecting it to surgical tests.

Osteoplastic (autoplastic, homoplastic, heteroplastic) cuneiform osteotomy, carried out according to standard methods, is a relatively simple, practical, and efficacious method for clinically testing and evaluating bone transplantation generally as an aid to surgical therapy.

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AN OPERATION FOR RECONSTRUCTION OF THE INADEQUATE ACETABULUM *

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The literal interpretation of the term, inadequate acetabulum, implies an inclusion of all dislocations resulting from inadequate retention properties of the acetabulum to the upward, anterior, or posterior thrust of the articulating femoral head. For the purposes of this presentation a loose interpretation has been placed upon the term, restricting its application to the acetabulum capable of retaining the head after reduction, and including a group of cases with no actual dislocation but with symptoms produced by slightly inadequate acetabular roofs. As will become obvious from the subsequent description, reposition of the head within the socket is a prerequisite to the application of the principle involved in the operation to be presented.

The illustrations, Figures 2 and 3, depict an inadequate acetabulum in a girl ten years of age, resulting from residual paralysis of anterior poliomyelitis. The onset of this illness occurred when the child was ten months of age and the residuum involved the right

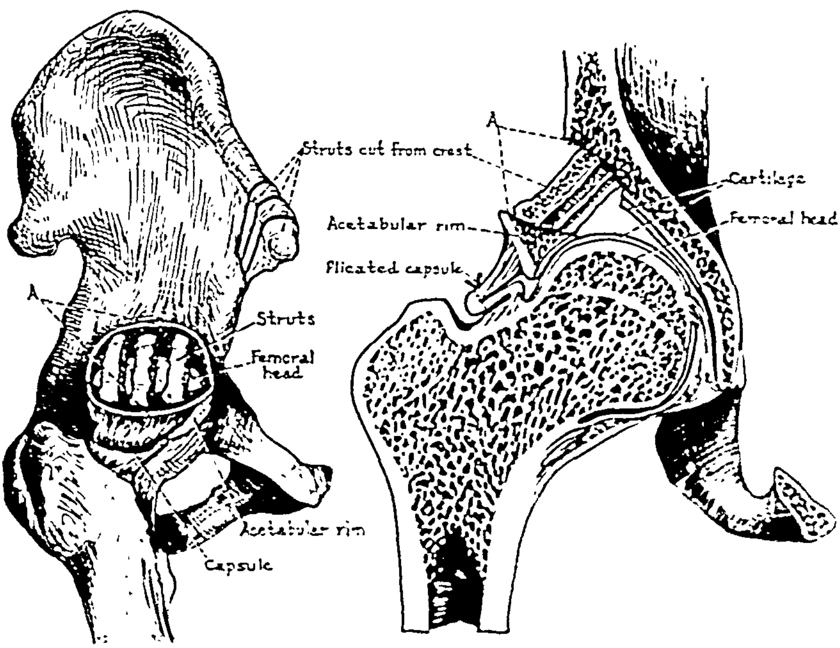

FIG. 1

A represents the distance that the acetabular rim is displaced laterally and downward to cup the femoral head. Its anterior and posterior pedicle attachments cause it to traverse an arc.

* From the Department of Surgery, Division of Orthopedics, The University of Chicago.

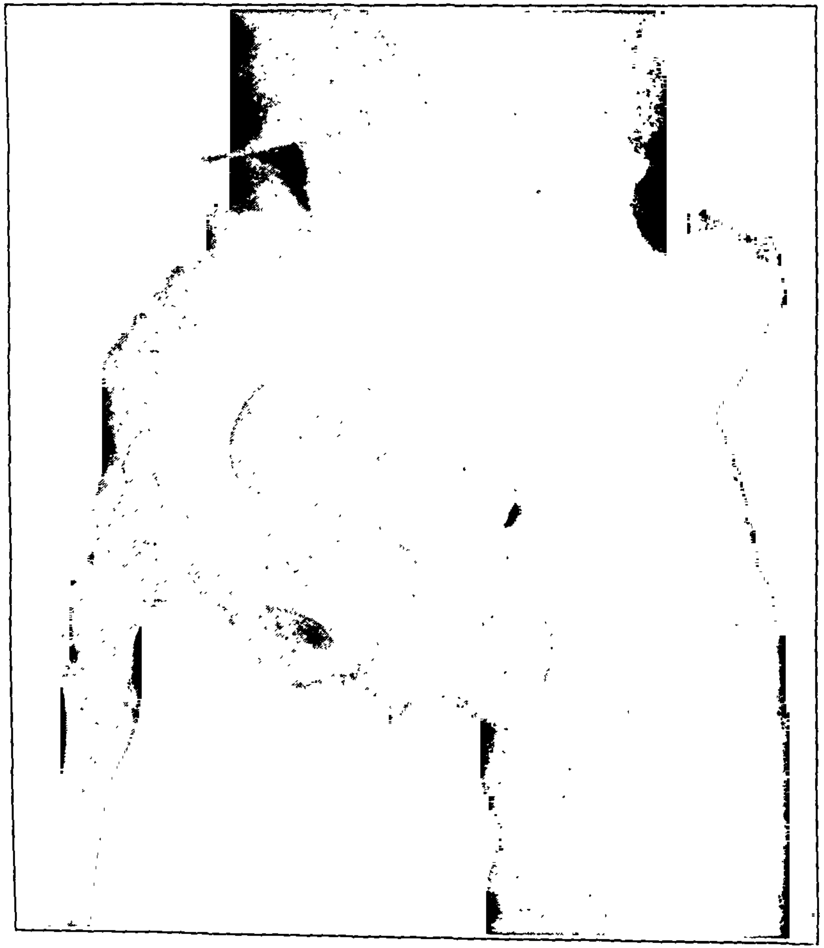

FIG. 2

An inadequate acetabulum of the right hip joint resulting from residual paralysis of anterior poliomyelitis. The femoral head could be dislocated and reduced with little effort.

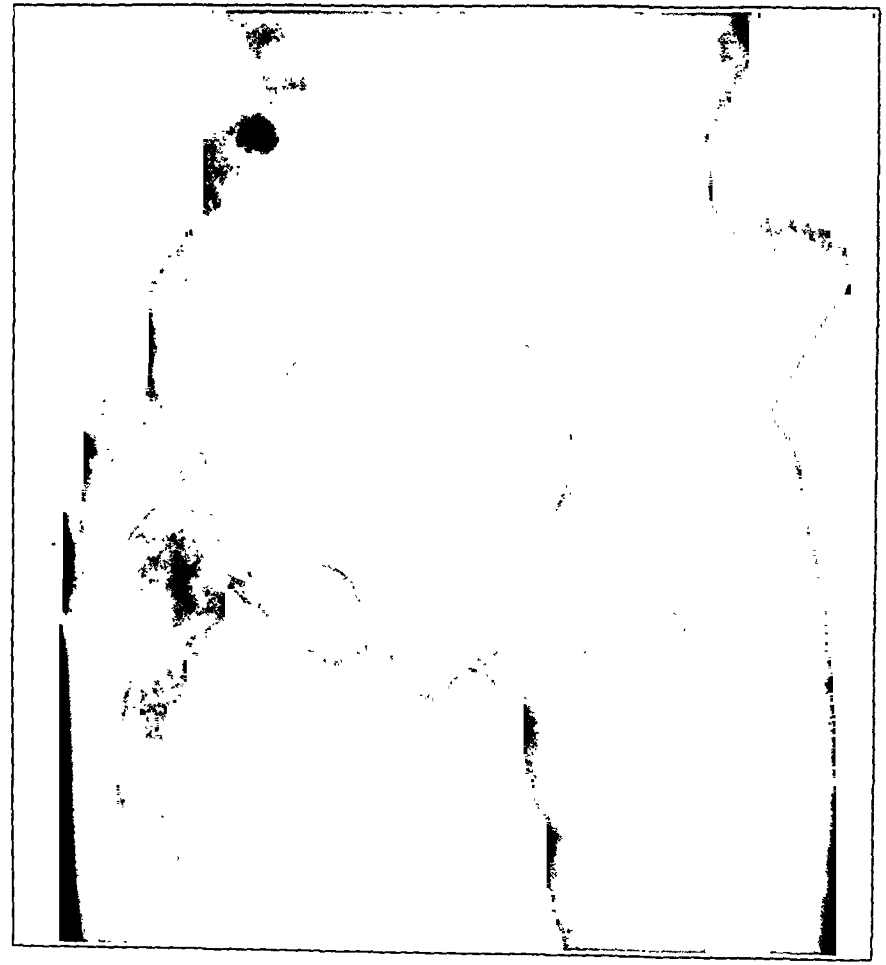

FIG. 3

Same patient. The femoral head dislocated upward by simply adducting the leg.

leg only. She learned to walk with the aid of a brace at the age of three. Since that time there has been a marked limp with an uncertain waddling gait which has become progressively worse. Upon examination there appeared a marked circumferential asymmetry of the two lower extremities and a length discrepancy of six centimeters. The neuromuscular systems were normal except for the right leg in which there was an almost complete loss below the knee and a partial loss (fifty to seventy-five per cent.) of the quadriceps, hamstring, adductor, tensor fascia lata, and gluteal muscle functions. The right femoral head dislocated upward with weight-bearing and with extreme passive adduction of the leg. There was a positive Trendelenberg and with the head dislocated, the trochanter presented well above Nélaton's line.

Four months after the operation (Fig. 4) the hip joint was completely stable with weight-bearing and could execute a full range of painless motion.

OPERATIVE TECHNIQUE

Through the usual Smith-Petersen approach, the periosteum is elevated from the outer table of the ilium until the upper half of the acetabular rim and the joint capsule are well exposed. If the femoral head is dislocated, it is (reduced) replaced within the acetabular cavity. This may necessitate opening of the capsule, release of an hour-glass constriction, severance of tight restricting bands (the Y ligament or iliopsoas) and the use of considerable traction and manipulation. The use of "skids" and other traumatizing instruments should be avoided.

FIG. 4

Same patient three months after the reconstruction operation illustrated in Fig. 1. Note the cupping relation of the displaced acetabular rim (A) to the femoral head. Note also the supporting struts (S).

Thus, with the head of the femur replaced, the acetabular rim is cut through into the joint with a thin-bladed osteotome over the proximal half of its circumference and pried laterally and downward in one piece as a pedicle attached at the extremities of the arc. Care is exercised to control the osteotome to avoid damage to the underlying femoral head. As the detached rim is displaced, it hinges as a bucket handle not only laterally, but downward in such a fashion as to cup the head. Struts are then cut from the crest of the ilium and interposed between the rim and the side of the ilium to hold the rim in its new position and to bridge the gap. If the capsule has been opened, it is now closed, and if redundant, plicated, and an anatomical restoration of the divided fascia and skin is effected. The hip is immobilized in moderate abduction in a plaster spica for a period of four to eight weeks.

With the removal of the cast, motion without weight-bearing and physiotherapy are carried out for four weeks. Early motion appears to promote new bone formation in the newly created shelf and to assure a wider range of motion.

This operation affords the advantages to be gained from a physiological and anatomical restoration which approaches the normal. It not only creates a roof which is continuous with the contour of the acetabulum, but also, to some extent, cups or circumvents the head of the femur. In consequence, maximum stability results. Likewise, since the joint capsule is carried down with the rim to which it is attached, it does not suffer impingement between the shelf and the femoral head, a condition existing after extracapsular shelf operations and considered by some observers to be a source of pain for a long time. Limitations to the use of the operation have been referred to.

THE TREATMENT OF JOINT LESIONS IN HEMOPHILIA BY MEANS OF WHOLE BLOOD FROM MENSTRUATING WOMEN

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The treatment of hemophilia has been as varied as its results. It has aimed to control hemorrhages by local applications of styptics, compression, absolute rest, fibrin ferment, and the various calcium preparations. Within the past few years blood transfusion has been found efficacious in controlling a single hemorrhage, but no lasting effects were noted from this method.

Minot and Lee [1] have made an observation that normal platelets added to hemophiliac plasma initiated prompt clotting. It is upon this principal that whole blood acts. The platelets found in normal blood liberate a ferment prothrombin, which combines with the calcium in the plasma and forms thrombin. The thrombin combines with the fibrinogen, and results in fibrin, an element necessary in blood clotting.

Grant,[2] in 1904, advised the use of ovarian extract in the belief that the ovaries had a protective influence against hemorrhage tendencies. He administered two and one-half grains of sheep's ovarian extract three times a day.

Gonzalez Alvarez,[3] in 1925, published an article on the treatment of hemophilia; the arguments and data presented by him sustain the view that hemophilia is the result of a congenital infection attacking the endothelial structures of blood vessels, and is usually of syphilitic origin. Women are protected, he thinks, by some hormone, and he suggests treatment of hemophilia with ovarian extract to simulate conditions in the female, besides supplying the lacking thrombin artificially.

Birch[4] more recently, advised this treatment, and speculated on the same theory, stating that the symptoms are held in obeyance in the presence of female sex organs. Two patients were treated by her during eleven and one-half months, and bleeding was controlled during that period. She states that the blood platelets in hemophiliacs have a greatly increased resistance both to hypotonic and hypertonic salt solution. When the resistance of hemophiliac platelets is overcome mechanically, the blood coagulates in normal time.

During the past years the author has treated cases of hemophilia according to accepted methods. The results were in accordance with those of others. The patients who come to bone surgeons are not the usual hemophiliacs who seek relief from repeated superficial hemorrhages; they are those seeking relief from joint affections.

Koenig [5] states that there are three forms of arthritis in hemophilia: (1) the simple hemarthrosis, with single repeated hemorrhages into the joints, with pain and limitation of motion; (2) the form associated with an inflammatory process in the joints, hemarthrosis and exudation into the

joint, and changes in the synovial membrane and capsular thickening, with organization of the exudate resulting in fibrosis, limitation of motion, swelling, discoloration of joint surface, fever, and often simulating tuberculosis; (3) the chronic inflammatory change in the joint with destruction of the articular cartilage, resembling arthritis deformans.

Two cases which are here described were boys who gave a history of bleeding since infancy. One boy had a tonsillectomy and when one tonsil was removed, the hemorrhage was uncontrollable, and the bleeding continued for six days, in spite of all measures to control it. Blood transfusion was resorted to for the control of this hemorrhage. Both cases were treated for years with all the known methods with no avail. Blood transfusion and whole blood intramuscularly were employed from time to time. The first boy bled from a needle puncture of the ear for two days. The coagulation and bleeding time of both cases was very much delayed. It was then decided to give these cases ovarian extract. This was done for a short time, but there was no change in the joint affections. Following this treatment, it was decided that, since ovarian extract is given on the basis that it adds an element contained within the female sex organs which has an effect upon the coagulation time of hemophiliacs, the blood of women during the period of the menstrual cycle might supply that ingredient in a more direct way. The first boy was therefore given ten cubic centimeters of whole blood intramuscularly every other day, taken from his mother during her menstrual period, and increased at the height of that cycle to fifteen cubic centimeters. The history and results follow:

Case 1. Boy, six years old, of good physical development, was brought for examination because of swelling and pain, and flexion contracture of the right knee and right elbow joints. The mother stated that the condition in the joints developed about a year before when she noticed discoloration, pain, and limitation of motion, and swelling of the right knee. The child was unable to walk on account of pain and contracture of the knee joint.

Past history: There were two children in the family, a girl twelve years of age, and the boy. Since birth the boy had shown signs of bleeding. Following his circumcision, he bled so extensively that two transfusions were resorted to for control of the hemorrhage. At one time he bit his tongue and an uncontrollable hemorrhage followed. The mother stated that whenever he injured himself there followed a blue discoloration in the skin. There were numerous blue discolorations over his legs, thighs, elbow, and lip.

Family history: Mother stated that she could not remember any male in her immediate family who had hemophilia.

Findings on examination: On examination the child proved to be a well developed boy for his age; the heart and lungs were normal; there were numerous discolorations on the extremities, showing recent and old bruises. A cut on the lower lip was oedematous and discolored. The right knee joint was flexed to about forty-five degrees; the muscles were spastic. There was considerable pain on movement. The knee was distended, discolored, and there was distinct limitation of motion. The right elbow joint was tender, painful on motion, and could not be fully extended. There were dark bluish discolorations on the extensor surface.

Blood examination: Aside from coagulation time, no studies of the boy's blood were made, prior to the institution of the present treatment. At the time of the first adminis-

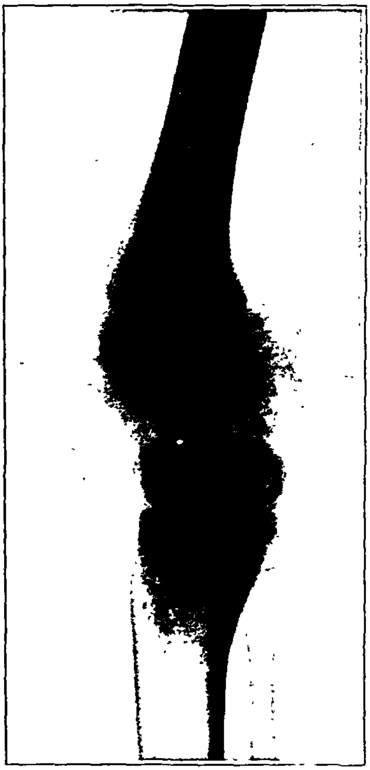

FIG. 1

Roentgenogram taken November 20, 1930, shows lateral view of the right knee joint. The knee is considerably larger, and shows in the infrapatellar space an irregular dark shadow, surrounded by a density which fills the entire knee joint. This is due, perhaps, to an exudate of a hemorrhagic nature, which has assumed a fibrinous character. The patella is very small and irregular. Its surface is ragged and its center is decalcified, showing areas of vacuolization. The articular cartilage of the femur is streaked, ragged, irregular, and thin. The articular cartilage of the tibia is rim-shaped and narrow, surrounding a spongy-appearing, subchondral, cancellous bone end.

FIG. 2

Roentgenogram of knee joint of same patient, taken sixteen months later, showing joint of approximately normal contour. There is a slight difference in size of the two joints. The infrapatellar space is clear. The patella approaches the normal; it is slightly larger than in Fig. 1. There is considerable ossification of the ends of the bones. The articular cartilage is more uniform, but still shows a slight ragged appearance in its upper portion. The interarticular space is not diminished.

tration of his mother's blood, coagulation time was markedly delayed, taking hours for coagulation. Whenever blood was taken from the lobe of the ear for examination, bleeding would follow for a day thereafter, leaving a slight bluish discoloration around the needle puncture. When blood transfusion was given, the oozing from the vein and from the surrounding tissue continued for several days. The last blood transfusion was given in October, 1930. Following the blood transfusion, whole blood was given him intramuscularly from a male donor; there would result some remission of the symptoms, but at no time was there a complete absence of bleeding, nor were the joints at any time normal.

In August, 1931, it was decided to give the boy whole blood intramuscularly, taken from his mother during her menstrual period. Ten cubic centimeters of blood was injected in the gluteal region every other day during his mother's menstrual period, and

these injections have been continued every month to this date. After the first administration of fifty cubic centimeters of his mother's blood, no evidence of recent bruises could be noted. At the present writing, eleven months after the beginning of treatment, there is free motion of the joints, no pain, no swelling, and no discoloration. The platelet count is 400,000, and the coagulation time is from ten minutes to a half-hour. The coagulation time was taken after each injection of blood.

CASE 2. *Boy, fourteen years of age, who gave a history of repeated and frequent* hemorrhages from the slightest injury or bruise. A tonsillectomy was performed on him some years ago, and after one tonsil was removed, the bleeding was so profuse that all palliative means failed to control the hemorrhage; a blood transfusion had to be done. Every manner of treatment was instituted to hasten coagulation, but all methods failed. On examination the tonsil bed looked hyperaemic and congested, with no signs of healing. There was a constant bloody serous discharge from the tonsil bed. Two-hundred and fifty cubic centimeters of blood was given the boy intravenously; and the hemorrhage promptly subsided, and the tonsil bed healed. He was started on ten cubic centimeters of his mother's blood intramuscularly, administered every other day during her menstrual period. Since the administration of his mother's blood he has been free of all evidence of bleeding.

Although it is evident that no definite conclusions can be drawn from two cases, and although the time may be too short to draw definite conclusions, yet this report is made to arouse interest in others who are confronted with the problem of treating hemophilia. The administration of whole blood intramuscularly is associated with no danger. The method can easily be carried out, giving the patient's mother's blood during her period of menstruation, and continuing for a few days thereafter. This is a method worth trying in combatting hemorrhage in hemophilia.

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INTRAPELVIC PROTRUSION OF THE ACETABULUM (OTTO PELVIS)

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The condition to be described may be defined as a non-traumatic, chronic progressive arthritis of the hip joint, characterized by intrapelvic protrusion of the acetabulum and head of the femur.

This lesion was recognized more than a century ago (1824) by Otto[1], and, although occurring infrequently, is of sufficient importance to orthopaedic surgery and obstetrics to justify a review of the subject. An indication of the timeliness of the latter was demonstrated recently by the report [42], of a case designated as "an unusual bilateral condition of the acetabulum", which apparently presented the typical features of an Otto pelvis. It should be stated at the outset that the association of Chrobak's name with that of Otto in connection with this disease is misleading, the former name having been attached by Eppinger [12], merely as a birthday tribute to Chrobak.

Diagnosed initially by Otto as "an abnormal gouty manifestation", this deformity has since been referred to by its reporters under the following diversified captions; Gurlt (quoted by Henschen [29]) referred to it as "a coxalgia with an acetabular fracture"; Eppinger (1903) suggested the term "*Coxarthrolisthesis-Becken*"; Kuliga (1905) referred to it as "an osteo-arthritis deformans"; Breus and Kolisko (1912), as "a peculiar destructive coxitis preferably localized in the acetabulum"; Schlagenhaufer (1908), as "gonorrhoeal arthritis"; Henschen (1909), as "caused by various processes of coxitis and neuropathy"; Schertlin (1911), as "a juvenile osteo-arthritis deformans"; Kienböck (1911) reported "an unusual deformity of the hip with protrusion of the acetabulum attributable to gonorrhoeal arthritis and tabetic arthropathy"; Chiari (1912) referred to this affection as "a tabetic coxarthritis"; Hertzler (1922), Pomeranz (1925), and Lewin (1925), as "an osteo-arthritic protrusion of the acetabulum"; Doub (1929), as "an intrapelvic protrusion of the acetabulum"; etc.

This disease was originally described by Otto[1] in 1824. As his description of a pelvis seen in an anatomical museum is the basis of all subsequent studies, the translation of it is presented as follows:

"This pelvis from an adult woman is, on the whole, fairly normal in size and build, its chief characteristic is the very deep insertion of both femoral heads in the acetabula; so that the floors of the latter protrude far into the pelvis and are at the same time imperfectly ankylosed.

"The right acetabulum protrudes into the pelvis like half an orange. It forms a round, smooth, fairly thick-walled, bony shell (all diameters of the base are two and three-quarters inches broad; from that point it protrudes into the pelvis one and one-half inches). At the crest (which approximately corresponds to the center of the acetabular

FIG. 1

Section illustrating the typical deformity. Reproduced from Breus and Kolisko by courtesy of the publisher. (*Die Pathologischen Beckenformen.* Wien, Franz Deuticke, III, 558, Fig. 150, 1912.)

fossa is an irregular circular defect, measuring one and one-half inches, probably due to absorption, initially possibly closed by membrane, but now supplying communication between the acetabulum and abdominal cavity. The lower marginal portion of the ilium protrudes like a ball into the iliac notch, due to the extended acetabulum, so that its ordinary width of about two inches, as well as the distance between the tip of the os sacrum and the opposite iliac margin, is reduced to one inch. The acetabulum protrudes so far into the pelvis that it contains not only the head but also the normally long neck of the femur, and the upper acetabular margin articulates with the great trochanter. The entire inner aspect of the acetabulum is smooth, also the head of the femur; both are devoid of cartilaginous covering, and have the abraded and polished appearance of some gouty joints; only the portion of the femoral head opposite the acetabular defect is roughened and eroded by absorption. The acetabular margin is rough and uneven, slightly thickened, and so constricts the femoral head that the larger head cannot be removed from the cavity of the joint,—the transverse ligament of the acetabulum is ossified. (Since the roughened large trochanter grates on the roughened acetabular margin, and since the femoral neck is also somewhat angular and the small trochanter hits the sciatic tuberosity on backward flexion of the femur, the femur itself can be rotated only slightly forward and inward, but not outward and backward; thus the joint is so restricted that the abdomen and thighs form a right angle in the standing position.)

"The left hip joint behaves much like the right; its acetabulum does not protrude, however, quite so far into the pelvis, but only three-quarters of an inch; the neck of the femur also has not entirely dropped down into the acetabulum, yet, since the margin is thicker than in the right hip and more constricted, and since the neck of the femur shows several protuberances at the points of friction with the acetabular margin, movement is still more restricted; the arc described by excursion of the left knee anteroposteriorly is only seven inches long; the inner bilateral femoral tuberosities can be separated only for a distance of about four to five inches. In the left hip joint the transverse ligament is ossified and is three-quarters of an inch in breadth.

"The right sacro-iliac symphysis is ankylosed for about one inch, and because the right femoral head is deeply inserted, the lower end of the right femur appears to be shorter than the left by one inch.

"From the above described deformity and the whole appearance of the bone of this specimen, which is of interest to obstetricians, I believe the condition due to abnormal gout."

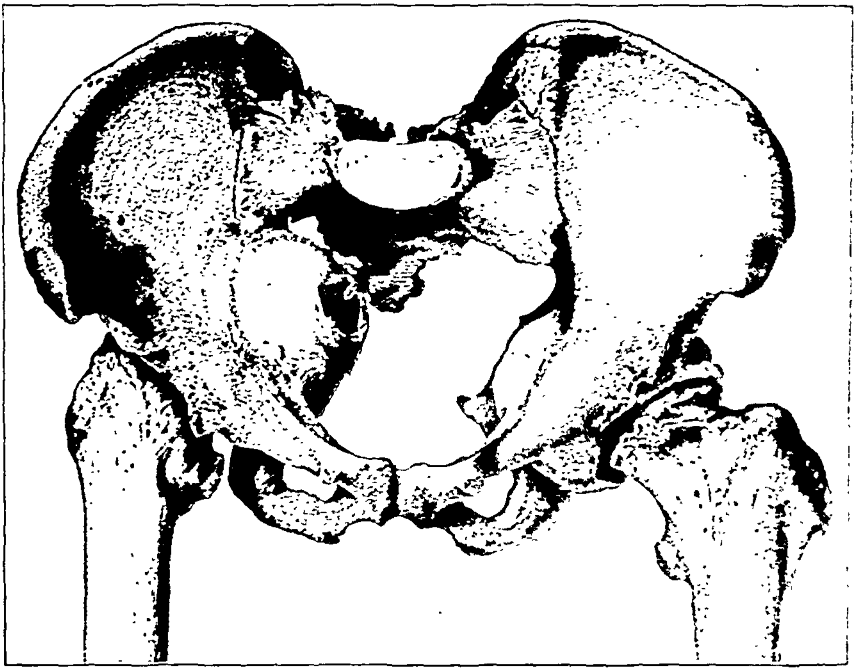

FIG. 2

Otto's original case. Reproduced from Breus and Kolisko by courtesy of the publisher. (*Die Pathologischen Beckenformen.* Wien, Franz Deuticke, III, 540, Fig. 142, 1912.)

The reproductions Figures 1 and 2 were obtained from Breus and Kolisko[27] and illustrate the typical deformity.

ETIOLOGY AND PATHOGENESIS

Differences of opinion regarding this disease have been occasioned chiefly: (1) by the wide range of etiological factors held to be responsible for the condition, and (2) by variations in the pathological findings reported. Based on the theory of various investigators that numerous transitional forms are possible, it appears that opinions might easily be influenced by the particular stage during which the process is noted; also by the fact that quantitative and individual fluctuations in the severity of the lesions must be reckoned with. Then, too, transitional forms may be missed at autopsy, although present, since the hip is not usually investigated *post mortem.*

A review of the literature in connection with the Otto pelvis points to an overwhelming majority who believe that it is not a disease entity, but the end result of an inflammatory process: Wolfsohn and Brandenstein, Schlagenhaufer, Bischoff, Schertlin, Daub, Henschen, Kienböck, Breus and Kolisko[27], Kuliga, Pomeranz, Loebl, Zwicker, Campbell, and Saupe are in approximate agreement with this view. Many of these writers regard the condition as an extension of ..

juvenile osteo-arthritis or other chronic deforming process, the deformity being manifested years after recovery from the original acute infection.

Numerous bacterial agents are variously believed to be concerned in the process, including the tubercle bacillus, the gonococcus, the streptococcus, etc. Such conditions as tabes, lues, metastatic malignancy, the arthritides, gouty diathesis, coxitis, chondrodystrophy, and trauma are among the other important factors believed, from an etiological standpoint, to be actively concerned.

Eppinger's article [12] appears to be the first scientific dissertation on the subject. From his study of four anatomical specimens, he attributed the affection to a disturbance in the acetabular development, of the nature of a chondritis or chondrodystrophy. Stated otherwise, he considered it a developmental anomaly of the acetabulum in which the persistent cartilage does not fuse, but is projected into the pelvic cavity; nevertheless he differentiates this condition from the chondrodystrophy of the dwarf or of the rickets type. His disregard of the tuberculous history in three of the four cases he described excluded, in his opinion at least, any causal relationship.

Kuliga [13] questions the importance of the cartilaginous changes, believing them to be secondary involvements. His case is of extreme interest, since it bears on the obstetrical significance of the lesion. His patient died of hemorrhage following delivery, and at autopsy a typical Otto deformity was found. This author considered it an osteo-arthritis and does not agree with Eppinger's theory of a chondrodystrophy. This was the first case which correlated the clinical and pathological material. In Benda's case [36] the intrapelvic protrusion interfered with labor, and a Caesarian section was performed. A female child was delivered on whose head a globular defect was noted. This pressure defect disappeared in a few days. This case contradicts Henschen's statement that unilateral cases would not produce obstruction in labor, nor would they hurt the soft tissues of the child or mother. Henschen [18] believes with Schlagenhaufer [21] that it was of gonorrhoeal origin.

The tuberculous basis of the condition, however, is suggested by several writers including Valentin and Müller [32]. Henschen [20], although excluding tuberculosis from the possible etiological factors, calls attention to the occurrence of a similar protrusion in the temporomandibular articulation in phthisis. Again, Hertzler [33] would exclude not only tuberculosis in the causation of this anomaly, but also tabes and osteomyelitis, and regards the affection as an osteo-arthritis. Chiari [31] disregards the history of tuberculosis in four of the eight cases which he reported; he also rejects the gonococcal theory, and reaffirms his original contention [28] of the tabetic etiology of the disease. Zwicker's [38] Cases 4 and 5 are evidently tuberculous in origin. Tregubow's [43] cases are obviously due to tuberculosis of the hip with perforation of the acetabulum. Although he described them as Otto pelves, they lack the protrusion and hyperostosis of a true Otto pelvis

Féré [8] and Wrede [22] subscribe to the tabetic theory, and Bischoff [25] considers the etiological connection of tabes of interest in that it may explain the absence of more marked pain. White [9], in 1884, described a specimen from a woman found in the dissecting room of Guy's Hospital. The acetabular fossae protruded into the false pelvis. In view of the absence of productive changes, this writer doubted the luetic origin of the condition and submitted the specimen to Féré who in turn submitted it to Charcot. The latter identified it as a luetic arthropathy. White in a subsequent communication [9] stated that he was uncertain how to classify the lesion, and questioned the significance of the luetic history. On the other hand, Breus and Kolisko [27] hold the tabetic theory untenable because of the recent manifestations in the right hip joint in Chiari's [28] Case 8, an old destructive protrusion being present in the left hip joint. Yet this case was clinically and autoptically confirmed as due to tabetic arthropathy.

Several authors have stressed the rôle played by the gonococcus. Schlagenhaufer [21], in 1909, described a case which has often been quoted. This was a female patient forty years of age, in whose hip joint the gonococcus was found at autopsy. The joint changes were those of a typical destructive arthritis, with protrusion of the acetabulum and the head of the femur. Although convinced that the condition he presented was the extension of a gonorrhoeal arthritis, this investigator conceded that other inflammatory processes than one of gonococcal origin might theoretically also produce the same changes. Schlagenhaufer's case was regarded by Henschen [29] as the only case of intrapelvic acetabular protrusion of gonorrhoeal origin bacteriologically confirmed up to that time (1913). Breus and Kolisko [27] described three cases of Otto pelvis. They acknowledged as the only positively established etiological factor a gonorrhoeal coxitis, and rejected Henschen's suggestion of a tuberculous or tabetic origin. Breus's subsequent study [30] convinced him that the gonococcus was the only bacterium capable of producing all of the changes and sequelae noted in this condition. Although Kienböck [illegible] claimed that protrusion of the acetabulum was a rare finding in gonorrhoeal arthritis, nevertheless he attributed one of his cases to this source. His second case he believed due to a combination of lues and gonorrhoea. His explanation was that the gonorrhoeal arthritis caused rapid softening of the acetabulum with trophic disturbances of the bone; and that tabes caused gradual trophic disturbances of the bone with erosion and protrusion of the acetabulum and ossification of the periosteum. Zwicker's [28] Case 7 developed an intrapelvic protrusion after an acute gonorrhoeal infection.

The importance of metastatic malignancy as a causative agent in the production of this deformity has been discussed by several authors. In Thomsen's case [4] evidence of the neoplasm was found at autopsy.

Chiari [28] reported the case of a man (Case 7) who died of carcinoma of the biliary tracts, and Valentin and Müller [illegible] regarded Case 1 of their series as a case of a highly ossifying carcinoma.

The rôle played by trauma in Ponfick's [3] case, in a woman of fifty-one who sustained an injury sixteen years prior to the development of the lesion, has caused much controversy. This patient also had tabes which developed during pregnancy. Chiari [31] attributes the deformity in this case to trauma, and he considers Féré's and Henschen's [20] Case 2, as due to a combination of traumatic and gonococcal causes. It is probable that Benda's [36] case was traumatic in origin. Of the cases reported by Saupe [40], Cases 1, 2, and 3 are traumatic in origin.

Henschen [20] reported seven cases of echinococcus infection cited in the literature and indicated that the diagnosis usually was not made *intra vitam*, but at operation or autopsy. Granular destruction of the acetabulum and perforation were usually seen, and the acetabular fossae were sequestrated and punched out. The heads of the femora were usually involved in these cases. According to Kroenlein [7], echinococcus involvement occurs first in the soft tissue of the joint and secondarily in the bone. Trendelenburg [6] described the case of a man, thirty years of age, who had a suppurating fistula in the right hip. Rectal examination made at operation revealed a bony elevation near the acetabulum, the size of a fist and surrounded by echinococcus vesicles. A sequestrum was found within the acetabulum. This patient recovered following a resection. Doebbelin [11], in reviewing seventy-eight cases of echinococcus infection of the osseous system, reported pelvic involvement in twenty-three, and in only three cases had the infection spread from the pelvis to the femur. He reviewed the cases of Trendelenburg [6], Pihan [2], and Réczey [5].

Esau's case [16] (previously referred to) in a girl, ten years of age, who was suddenly seized with pain in the lower abdomen and died four weeks later, was diagnosed by him as an acute pyogenic osteomyelitis of unknown etiology. From the extensive bony destruction this investigator assumed that the process had its origin in the pubic bone, thence spreading to the acetabulum and ischium, and resulting in intrapelvic protrusion of the acetabulum. Froelich [44] described typical cases occurring in women, both of whom had been operated upon for tumors of the ovaries. In this connection, he called attention to a similar case reported by Verrall, and believed the deformity of endocrine origin.

The predominating characteristics as postulated by Henschen [18], in 1909 are: protrusion of the acetabulum; elevation of the rim of the acetabulum with eburnation; preservation of the femoral head and its migration into the acetabulum, and shortening of the extremity. On the other hand, four distinct stages of the process have been described by Breus and Kolisko [27],—namely:

(1). A localized destructive inflammation of the bony acetabulum.

(2). An almost complete preservation of the head and neck of the femur in the longitudinal axis.

(3). Intrapelvic protrusion of the acetabular periosteum, due to pressure from the femoral head.

(4). A rapid, smooth healing, resulting in a newly formed acetabular floor and permanent, dome-shaped, intrapelvic protrusion.

These investigators, including Henschen[29], believe that extension of the acetabular floor occurs during the initial stage; that development of the dome-shaped periosteum takes place during the intermediate stage; and that, during the terminal stage, periosteal ossification with definite Otto protrusion may be observed. A suggestion of this is seen in Schlagenhaufer's statement [17] that the following may be similar cases observed at different stages of the disease:

1. Schlagenhaufer's case.
2. Eppinger's Pelvis A.
3. Eppinger's Pelvis B.
4. Kuliga's case.
5. Eppinger's Pelvis 6 with Case 1, Breus and Kolisko.
6. Eppinger's Pelvis D, with Otto's Case 1, and Case 2 of Breus and Kolisko.

This last stage may be succeeded by various secondary bony changes of the joint, by hyperostosis, sclerosis, partial or total synostosis. Henschen and Breus and Kolisko are convinced that in the development of this disease the outstanding change occurs in the acetabulum, the femoral head being relatively uninvolved or secondarily involved; and Bischoff[25], Doub[41], and the writer [31] are in approximate agreement with this view. On the other hand, Otto[1], Ponfick[3], Féré[8], and Schlagenhaufer[21], have found the predominating changes in the femur, the head in some instances being practically denuded of cartilage and covered with granulations.

INCIDENCE

Valentin and Müller[32], in 1921, summarized thirty-one of the thirty-four cases reported up to that time, and of these only twenty were conceded by them to be typical. Their analysis is probably correct, if Case 2 of their series is included. Since that time forty-five additional cases have been reported, and of these twenty-one appear to be typical instances of intrapelvic protrusion, making in all approximately forty-one cases of true Otto pelvis reported to date. Despite the few recorded cases, the literature which has accumulated on the subject is truly enormous. Curiously enough this affection had been studied chiefly by the Germans, Hertzler's publication being the first American contribution on the subject.

In forty-seven of the seventy-nine cases reported, this deformity occurred in females. It is thus almost twice as common in females as in males. Persons in middle life have been most generally affected, the outstanding exceptions being one patient of advanced age—Chiari's Case 2, a man of seventy years,—and the following cases reported in individuals under twenty years of age,—Esau's case in a girl of ten; Zwicker's Case 4, in a girl of fifteen; Doub's Case 1, in a young woman of sixteen; and two young women, eighteen and nineteen years of age respectively, Valentin and Müller's Cases 2 and 3.

The disease was unilateral in forty-nine of the seventy-nine reported cases. In twenty-nine, the condition was bilateral; and in one case the side involved was not stated by the author.

CHART OF REPORTED CASES OF INTRAPELVIC PROTRUSION OF THE ACETABULUM (OTTO PELVIS)

Author	*Year Published*	*Author's Case No.*	*Age*	*Sex*	*Side*	*Author's Diagnosis*	*Pertinent Data*
Otto	1824	o1	?	F	Bilateral	Gout	Specimen. Associated arthritis of sacro-iliac joint.
Pihan	1860	x1	27	M	Right	Coxitis	History of injury, followed by pyarthrosis. Echinococcus cysts found at autopsy. This case was reviewed by Doebbelin[11], and Tillmanns[14].
Ponfick	1872	o1	51	F	Right	Arthritis deformans	History of injury and tabes. Arthritis of hips and knees. Believed by Schertlin to be a typical case, but rejected by Breus.
Thomsen	1872	x1	40	F	Right	Metastatic malignancy	Operated upon for carcinoma of the breast. Autopsy revealed metastatic malignancy of the right hip.
Réczey	1877	x1	27	F	Right	?	Greatest protrusion of the acetabulum reported. Autopsy revealed echinococcus cysts. Reviewed by Doebbelin[11] and Tillmanns[14].
Trendelenburg	1881	x1	30	M	Right	Pyarthrosis	Echinococcus cysts found at operation. Reviewed by Doebbelin[11].
Féré	1882	x1	?	?	Right	Tabes	Specimen. Insufficient data.
White	1884	o1	?	F	Right	Charcot's disease	Specimen. Confirmed by Charcot. Believed by Schertlin to be typical case but rejected by Breus.
Eppinger	1903	oA	45	M	Right	Anomaly of growth	Specimen. Patient had pleurisy and tuberculous testicle. Probably tuberculous in origin. Accepted by Breus as a typical case.
Eppinger	1903	oB	35	M	Right	Anomaly of growth	Specimen. Patient had pulmonary tuberculosis, tuberculous caries of the spine, and tuberculous peritonitis. Accepted by Breus as a typical case.
Eppinger	1903	oC	?	F	Bilateral	Anomaly of growth	No data. Specimen. Henschen would exclude this case. Considered typical by Breus.
Eppinger	1903	oD	34	M	Left	Arthritis deformans	Miliary tuberculosis of the lungs, spleen, kidneys, and tuberculous adenitis. Accepted by Breus as true case.
Kuliga	1905	o1	45	F	Bilateral	Osteoarthritis	First case reported having obstetrical difficulties. Autopsy confirmation. X-ray plates show typical deformity. Henschen and Schlagenhaufer consider this case of gonorrhoeal origin. Accepted by Breus as typical. Reviewed by Von Rosthorn[15].

CHART OF REPORTED CASES OF INTRAPELVIC PROTRUSION OF THE ACETABULUM (OTTO PELVIS)—*Continued*

Author	*Year Published*	*Author's Case No.*	*Age*	*Sex*	*Side*	*Author's Diagnosis*	*Pertinent Data*
Esau	1908	x1	10	F	Right	Osteomyelitis	On puncture of hip, yellowish white pus was obtained which revealed chained streptococci. Autopsy confirmation. Evidently a true case.
Henschen	1909	o1	76	F	Bilateral	?	Tubingen Specimen 1. Died of cardiac disease. True case.
Henschen	1909	o2	?	F	Left	?	Tubingen Specimen 2. No data. Resembles Eppinger's Pelvis C.
Henschen	1913	o3	41	F	Bilateral	Coxarthritis or neuro-arthropathy	Negative Wassermann and complement-fixation tests.
Schlagenhaufer	1909	o1	40	F	Right	Gonorrhoeal arthritis	First study from clinical course to autopsy. Gonococcus obtained on autopsy from hip joint and tissues.
Schertlin	1911	o1	40	F	Bilateral	Juvenile deforming arthritis	History of polyarthritis of twenty years' duration. X-ray plates submitted. Breus considers the etiology incorrect, but may still be gonorrhoeal.
Wolfsohn and Brandenstein	1911	x1	34	M	Right	Juvenile osteo-arthritis	Condition evidently developed as part of polyarthritis. Connection with Otto pelvis not investigated. Rejected by Breus.
Bischoff	1911	o1	?	F	Bilateral	Arthritis deformans	Specimen. No history.
Kienböck	1912	o1	42	M	Bilateral	Tabes	History of gonorrhoea and syphilis. X-ray plates submitted.
Kienböck	1912	o2	32	F	Right	Gonorrhoea	History of gonorrhoea and eleven years later developed intrapelvic protrusion.
Breus and Kolisko	1912	x1	45	M	Right	Coxitis	Specimen. Patient died of pulmonary tuberculosis.
Breus and Kolisko	1912	x2	75	F	Right	?	Specimen. Patient died of acute purulent bronchitis.
Breus and Kolisko	1912	o3	?	?	Left	?	No history. Specimen loaned by Prague Pathological Museum.
Chiari	1916	o1	33	F	Left	Gonorrhoeal arthritis	Wassermann negative. Polyarthritis. On autopsy adnexa contained pus with gram positive and negative diplococci. Left hip contained pus which was negative for gonococci. Probably of gonorrhoeal origin.
Chiari	1916	x2	70	M	Right	Tuberculous or gonorrhoeal arthritis	Specimen. Patient died of genito-urinary tuberculosis. Insufficient data.
Chiari	1916	x3	?	M	Left	Tuberculous coxitis	Specimen. [illegible]

Chart of Reported Cases of Intrapelvic Protrusion of the Acetabulum (Otto Pelvis)—*Continued*

Author	*Year Published*	*Author's Case No.*	*Age*	*Sex*	*Side*	*Author's Diagnosis*	*Pertinent Data*
Chiari	1916	x4	?	M	Left	Tuberculous coxitis	Specimen. Insufficient data.
Chiari	1916	x5	43	M	Bilateral	?	Specimen. Died of tuberculosis of lungs and peritoneum.
Chiari	1916	x6	73	M	Bilateral	Arthritis deformans	Specimen. Insufficient data.
Chiari	1916	x7	71	M	Bilateral	Arthritis deformans	Died of carcinoma of the biliary tract.
Chiari	1916	o8	52	F	Bilateral	Luetic arthritis	Symptoms of lues with positive Wassermann. Autopsy findings of generalized syphilis. Case originally reported in 1912.
Valentin and Müller	1921	x1	50	F	Left	Neoplasm	Carcinoma of adnexa. Patient received radium therapy. Died of cachexia.
Valentin and Müller	1921	o2	18	F	Left	Tuberculous coxitis	History of rheumatism and pleurisy. Positive tuberculin test. Radiographs submitted.
Valentin and Müller	1921	x3	19	F	Left	Arthritis	Rheumatism with cardiac involvement. Complement-fixation and Wassermann tests negative.
Hertzler	1922	o1	29	M	Bilateral	Polyarthritis	Author identifies this case with those reported by Wolfsohn and Brandenstein, Schertlin, and Henschen.
Hertzler	1922	x2	44	F	Left	Polyarthritis	History of injury. Confined to bed with fever. Sinus formed. Believed this case similar to Esau's case.
Hertzler	1922	x3	36	F	Left	Tuberculous arthritis	Treated for a hip condition as a child. Similar case reported by Chiari.
Hertzler	1922	x4	46	F	Left	Metastatic malignancy	Tumor of breast removed by caustic agent. Similar case reported by Valentin and Müller.
Pomeranz	1925	o1	31	M	Left	Osteoarthritis	History of cholecystitis. Serology negative.
Lewin	1925	o1	64	M	Left	Osteoarthritis	History of injury. Specific urethritis twenty years prior to examination.
Benda	1926	x1	42	F	Right	Coxitis	History of injury followed by disability. Caesarian section. First obstetrical difficulty. May be traumatic in origin.
Loebel	1927	x1	63	F	Right	Polyarthritis	Polyarthritic symptoms for eight years.
Loebel	1927	o2	51	F	Bilateral	Arthritis	History of injury to spine and hips. Associated arthritis of the sacro-iliac joints.
Loebel	1927	o3	53	F	Bilateral	?	Four years' duration. Typical waddling gait.

Chart of Reported Cases of Intrapelvic Protrusion of the Acetabulum (Otto Pelvis)—*Continued*

Author	*Year Published*	*Author's Case No.*	*Age*	*Sex*	*Side*	*Author's Diagnosis*	*Pertinent Data*
Zwicker	1927	x1	56	F	Left	Arthritis	No data.
Zwicker	1927	o2	66	F	Left	Arthritis	Generalized arthritis of hips and knee joints.
Zwicker	1927	o3	?	F	Bilateral	Arthritis	Arthritis of the hip and knee joints.
Zwicker	1927	x4	15	F	Left	Tuberculous coxitis	Tuberculous arthritis. Involvement of the head of femur. Protrusion present.
Zwicker	1927	x5	26	M	Left	Tuberculous coxitis	History of injury followed by disability. Plates show ankylosing process in left hip.
Zwicker	1927	o6	?	F	Bilateral	Rickets	Old generalized rachitic deformities present.
Zwicker	1927	o7	?	F	Right	Gonorrhoeal arthritis	Hip lesion developed after gonorrhoeal urithritis.
Campbell	1928	o1	68	F	Left	Poly-arthritis	History of repeated attacks of rheumatism followed by deformities. X-ray plates show deforming arthritis of elbows, hands, and shoulders.
Campbell	1928	o2	64	F	Right	Poly-arthritis	History of polyarthritis of ten years' duration. X-ray shows chronic deforming arthritis of many joints.
Saupe	1928	x1	49	M	Left	Osteo-arthritis deformans	History of injury. Osteomyelitis of femur.
Saupe	1928	x2	52	M	Right	Osteo-arthritis deformans	Fracture of neck of femur, eleven years prior to observation. Probably traumatic.
Saupe	1928	x3	69	M	Right	Osteo-arthritis deformans	Injury to right hip, ten years prior to observation. Patient had Paget's disease. Probably fracture of acetabulum.
Saupe	1928	x4	?	M	Right	?	No data. Rejected.
Saupe	1928	o5	68	F	Left	Osteo-arthritis deformans	History of arthritis.
Saupe	1928	x6	?	?	?	Paget's disease	No data. Rejected.
Saupe	1928	o7	?	?	Left	Osteo-arthritis deformans	Specimen. No history. Associated destructive arthritis of right hip joint.
Saupe	1928	x8	?	?	Bilateral	Osteo-arthritis deformans	No data. X-ray plates only submitted. Ankylosing arthritis of numerous joints.
Saupe	1928	x9	?	?	Left	Osteo-arthritis deformans	X-ray plates only submitted. Insufficient data.
Saupe	1928	x10 11 12	?	?	Bilateral	?	No data. Rejected.

Chart of Reported Cases of Intrapelvic Protrusion of the Acetabulum (Otto Pelvis)—*Continued*

Author	*Year Published*	*Author's Case No.*	*Age*	*Sex*	*Side*	*Author's Diagnosis*	*Pertinent Data*
Doub	1929	o1	16	F	Bilateral	Osteo-arthritis	History of typhoid and injury to left hip. Plates submitted.
Doub	1929	o2	50	F	Bilateral	Osteo-arthritis	History of rheumatism and typhoid. Plates submitted.
Doub	1929	o3	49	F	Left	Osteo-arthritis	Associated arthritis of the spine. Radiographs submitted.
Doub	1929	x4	53	F	Bilateral	Osteo-arthritis	Arthritis of the hips and spine. Not typical case. Plates submitted. No protrusion present.
Doub	1929	x5	44	F	Bilateral	Osteo-arthritis	History of scarlet fever, measles, and influenza. No true protrusion of the acetabulum present. Plates submitted.
Doub	1929	x6	35	M	Bilateral	Osteo-arthritis	Osteo-arthritis, with no protrusion. Plates submitted.
Doub	1929	o7	?	F	Right	Osteo-arthritis	Cases of Dr. Henderson. Roentgenograms show typical protrusion.
Doub	1929	o8	40	F	Right	Osteo-arthritis	Appear to be typical involvement. Plates submitted.
Verrall	1929	o1	34	F	Bilateral	Artho-katadysis	Duration of twenty years. Operation for cystic ovary. Erroneous diagnosis of tumor palpable through vagina? Plates submitted.
Froelich	1930	o1	43	F	Bilateral	Intrapelvic protrusion	Discovered accidentally following x-ray examination for slight injury to right hip. Lesion antedated accident. No previous disability. History of operation for tumor of ovary at age of thirty-three.
Froelich	1930	o2	34	F	Bilateral	Intrapelvic protrusion	Progressive disability for past twenty years. No injury. Operated upon in 1922 for tumor of ovary. These cases resemble the one reported by Verrall.

x—Doubtful cases. o—Typical cases.

SYMPTOMS AND PHYSICAL FINDINGS

The chief complaint of the average case is that of a slowly progressing painful coxitis, which has lasted for months or years prior to the examination. With the coxitis, there develops a limp, which gradually becomes so severe that the patient walks with a wabbling gait and may find it impossible to spread the limbs or to stoop. If the deformity is great and the condition of long standing, all movements at the hip become completely restricted and walking is impossible.

Physical examination discloses distinct limitation of abduction and rotation of the femur. Outward rotation in particular appears to be restricted early in the disease. One may feel the greater trochanter grate against the pelvis or the lesser trochanter strike the ischium. The flexion deformity that occurs may be so great that the femur and pelvis form a right angle. Due to the migration of the femur, shortening of the extremity results. Kyphosis, lordosis, and pelvic rotation may be present, depending on the severity of the lesion in the hip. On abdominal palpation, a globular swelling, projecting into the pelvis from the inner aspect of the hip joint, may be felt above Poupart's ligament, and often in early cases the tumor may be readily demonstrated on rectal or vaginal examination.

ROENTGENOGRAPHY

The diagnosis even in early cases may be made by x-ray examination. The fundamental changes occur in the acetabulum. The disease results in an inward protrusion of the acetabulum, so that it projects into the pelvis as a rounded, globular, dome-shaped mass. The degree of protrusion varies from a few millimeters to four or five centimeters in severe cases. As the acetabulum migrates, it inclines upward, inward, and forward so that it may project above the ramus of the pubic bone, spreading towards the obturator fossa and at times materially encroaching upon and constricting it. In extreme cases, the protrusion extends up to the sacro-iliac joint and, as a result, unilateral constriction of the pelvis occurs. The inner wall of the acetabulum may be shell-like in thinness or else occur as an extremely dense eburnated wall. As it extends into the pelvis, a low-grade osteoplastic process is initiated, whereby nature splints the yielding joint by the formation of a dense wall on the inner aspect of the acetabulum parallel to its projecting margin. The external margins of the acetabulum project outward over the neck of the femur as irregular serrated vegetative formations.

In the typical deformity, there is preservation of the integrity of the femoral head. This would seem to be a necessary prerequisite, since the femoral head must maintain its boring qualities. This is in the main true of all cases reported, although many of the specimens examined reveal destruction of the cartilaginous covering of the head. Occasionally, there may occur slight deviations from the general configuration of the head. It may appear mushroomed and at other times slightly elongated, assuming a spear-like, or spade-like, shape. Projecting outward from the articular surface of the head, bony excrescences are present which extend over the femoral neck. The constricted acetabular inlet, combined with the osteophytic projections from the head, effectually locks the femoral head within the acetabulum. The futility of conservative measures in such a situation must be obvious.

As the femur follows the receding acetabulum, there appears to be foreshortening of its neck. This change, however, is more apparent than real and is due to two causes, - first, the upward extension of the ace-

tabulum, followed by the sinking head; and second, the osteophytic protrusion from the femoral head which occurs at the expense of the neck.

As the head of the femur is submerged within the acetabulum, the trochanters approach the lateral margins of the pelvis and incline posteriorly. The greater trochanter impinges on the lateral margins of the ilium, in the region of the acetabular shelf and the lesser trochanter approaches the ischium. The position of the trochanters explains why the femur cannot be rotated outward or backward. In extreme cases, the acetabulum may show two facets,—a superior and fairly large facet for the femoral head, and a smaller inferior facet for the lesser trochanter. The arrest of the trochanters at the lateral margins of the pelvis limits the deformity. Further inward migration of the femur is impossible, its boring action is suspended, and the periosteum on the inner wall of the acetabulum becomes ossified. The active stage of the disease is thus terminated and the deformity is permanent.

CASE REPORTS

CASE 1. Male, white, aged thirty-two, history number 10798. Admitted May 17, 1926, and discharged May 25, 1926. Diagnosis on admission: arthritis of the left hip.

Present History: In December 1921, the patient contracted a gonorrhoeal infection. Two weeks later his left ankle became inflammed and he was unable to support his weight on the involved extremity. He was treated by his family physician and the swelling subsided. Shortly after his recovery he took a four-mile walk, following which he experienced severe pain in the left hip. He was taken to an institution where he remained four months. At this hospital a plaster spica was applied to the hip for twelve days and his urethral infection treated at the same time. The pain subsided, but the hip became ankylosed. In December 1922, he entered another hospital and received baking and massage for six months. This treatment afforded him temporary relief, but the ankylosis of the hip remained. At still another institution which he visited, mobilization of the hip was attempted under a general anaesthetic.

Orthopaedic Status: Motion in flexion of the left hip was possible to only about forty-five degrees. Abduction was almost absent; internal and external rotation impossible. There was shortening of the extremity amounting to about three-quarters of an inch. There was no local tenderness over the involved hip, but a globular mass was present on the inner aspect of the acetabulum. The ankle joint was not involved.

Smear, complement-fixation, and Wassermann tests were negative. X-ray examination shown in Figure 3.

CASE 2. Male, white, aged forty-four. Admitted February 4, 1929, and discharged March 9, 1929. Diagnosis on admission: arthritis of the left knee and hip.

Present History: Four weeks prior to admission was confined to bed by influenza. This was followed by pain in left shoulder, wrist, knee, and hip in the order described. Received injections which relieved the pain somewhat. Three days prior to admission suffered excruciating pain in left hip and lower extremity. "Felt paralyzed."

Orthopaedic Status: Middle-aged, white, male, who was apparently in great pain. Patient lay in bed on left side with knees flexed. In the right lower extremity, there was no limitation of motion, but slight pain on pressure over gluteal fold. Left hip was held flexed but could be moved somewhat, although patient complained of pain in the hip and knee. There was marked tenderness over left groin on pressure. Left knee, negative. Spine, negative.

Temperature on admission was 102.8 degrees; respiration 32; and pulse 120. Throughout his stay in the institution his temperature ranged from 98.8 to 103 degrees.

Complement-fixation and Wassermann tests were negative. Blood chemistry showed 120 milligrams of sugar per 100 cubic centimeters of blood. First x-ray examination on February 4, 1929, shown in Figure 4. On February 7, 1929, patient noticed a thin mucoid discharge from the urethra, which bacteriologically was negative. On March 7, 1929, the contraction deformity of the left hip was corrected and traction applied. A cast was then applied which was removed on August 5, 1929. In December 1929, the patient was again seen, and at that time, a typical intrapelvic protrusion of the left acetabulum was revealed (Fig. 5).

FIG. 3

Case 1. Note intact femoral head. Sclerotic changes predominate, marginal spurs on acetabulum and head of femur.

CASE 3. Male, white, aged thirty-one. Admitted November 6, 1924. Diagnosis on admission: infectious arthritis.

The previous surgical history was negative. The previous medical history was of interest. While serving as a soldier in the latter half of 1917, he was taken acutely ill and was sent to a base hospital, where he was treated for a gall-bladder condition associated with fever. The patient's history indicated that the condition was a cholecystitis rather than a cholelithiasis. He remained in the hospital for one month and then was discharged as cured. No history of jaundice was obtained. Blood and serological examinations at that hospital were negative; as they were also at our institution.

Present History: Two weeks after discharge from the base hospital, while walking, he was seized with a sudden sharp pain in the left hip which soon became so severe as to incapacitate him. This pain was knife-like, and remained localized in the left hip. It was aggravated on walking and on exercise, and was somewhat relieved by rest. At the end of one week he was able to be up and about, the pain had left, but some disability remained. The past eight years witnessed a cycle of this sequence: a recrudescence of pain followed by relief after varying periods, to be succeeded by progressively increasing disability, so that at time of admission only limited motion was possible in the left hip

Orthopaedic Status: General condition and physical examination were negative except for the left hip. There was some muscular atrophy as well as a limitation of all movements about the hip except in flexion and extension. Abduction and external rotation were most restricted, adduction and internal rotation less so. X-ray examination, November 6, 1924 (Fig. 6).

CASE 4. Female, white, married, aged forty-four, history number [illegible]. Seen in the dispensary August 26, 1928. Clinical diagnosis, [illegible]

Previous History: Negative.

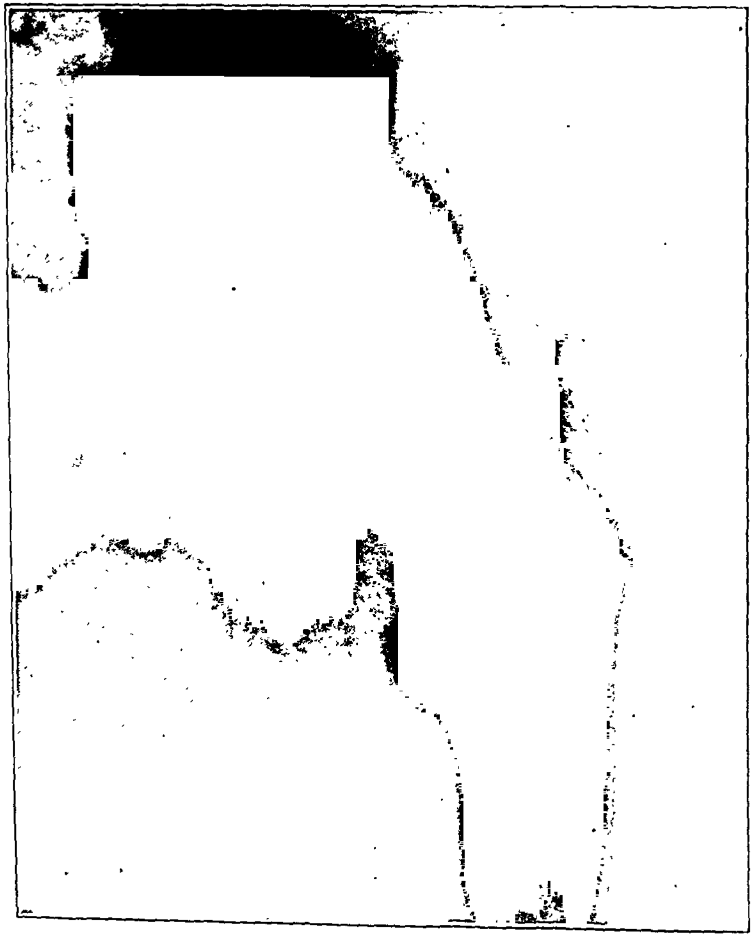

Fig. 4

Case 2. Complete obliteration of hip joint by destructive process, involving particularly the articular surface of the acetabulum. Femoral head intact.

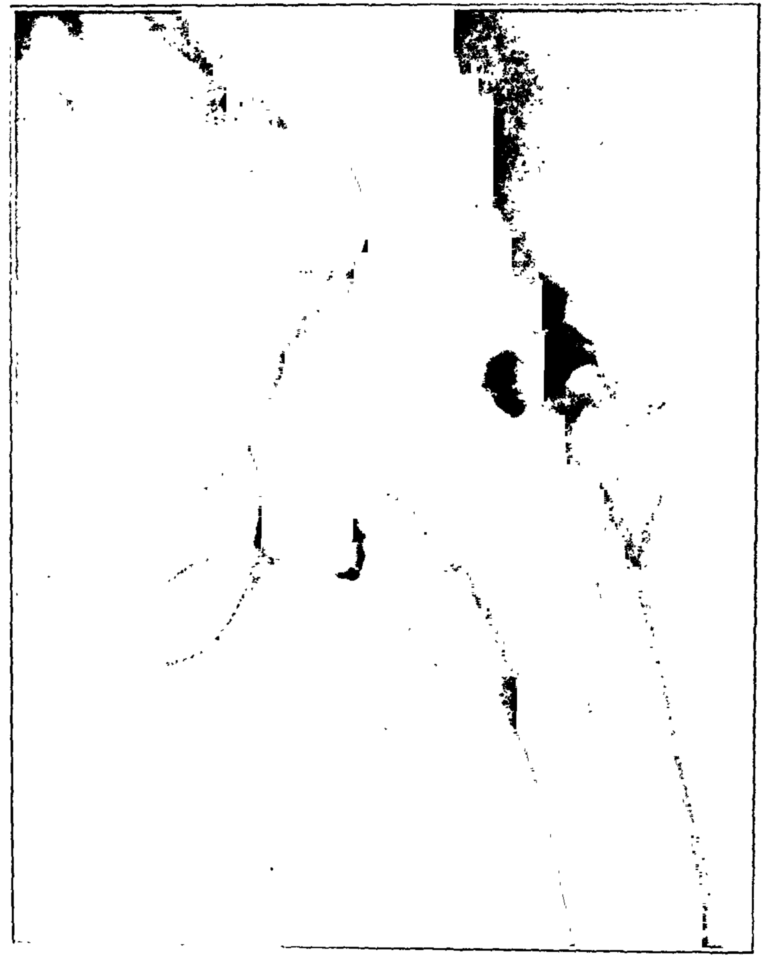

Fig. 5

Case 2. Same case as preceding, ten months later. Marked inward protrusion of the acetabulumate. Slight increase in the width of the joint space, with modern erosion of the head of the femur.

Present History: Pain in the sacro-iliac and hip joints for the past year, aggravated during the past three months. The pain appears to begin in the sacro-iliac regions and hip joints, and radiates down the thighs. Symptoms appear to be worse on the left side.

Orthopaedic Status: Patient walked with a waddling gait. Abduction and adduction of the thighs were almost impossible; rotation almost nil. Slight flexion deformities were present; further flexion was possible only when both thighs were flexed together. Both hips appeared to be partially ankylosed. There was marked tenderness over both sacro-iliac joints. X-ray examination, August 26, 1929 (Fig. 7).

Fig. 6

Case 3. Note vacuolated area in the newly formed inner surface of the left acetabulum. Bone abscess(?). Head of femur intact. Joint space clearly defined.

Case 5. Female, white, aged fifty-eight, history number 35245. Examined in clinic January 10, 1928. Diagnosis: polyarthritis.

Chief Complaint: Pain in the hips and right knee.

Previous History: Negative.

Present History: For the past three years patient had experienced irregular pains in the hips and right knee, most severe during inclement weather. The pain was dull in character, radiating from the back downward along both thighs. The pain in the back (in the sacro-iliac regions) was constant in character and relieved only by rest and heat. The pain in the hips and right knee was evanescent in character. For the past eighteen months, had noted increasing limitation of both hips.

Orthopaedic Status: Patient walked with a slight waddling gait. There was marked restriction of all movements in both hips, particularly on the right side. Rotation and abduction in particular appeared to be restricted. There was a moderate peri-articular swelling of the right knee joint without any restriction in motion. Varicose veins were present in both legs and examination of the feet revealed distinct tenderness over the heads of the metacarpal bones. No complement-fixation or Wassermann tests were performed. X-ray examination revealed fairly early and typical osteoarthritic protrusion of the acetabula, synostosis of the right sacro-iliac joint, and beginning ankylosis of the left sacro-iliac joint (Fig. 8).

Case 6. Female, white, married, aged thirty-two, history number [illegible]. Seen in the dispensary September 26, 1928. Clinical diagnosis: osteoarthritis of the hips.

Previous History: Negative.

Present History: The onset of the present condition began insidiously about eighteen months before, with slight pain in both hips. During the past year the pain had been more or less continuous and appeared to be worse on the right side, apparently beginning in the hips and radiating down the thighs. With the pain, there had been

some limitation in motion, particularly on the right side. During the past three months, there had been a vaginal discharge.

Orthopaedic Status: Flexion in both hips was markedly restricted. There was a moderate adduction contraction present, on both sides; abduction restricted. No rectal examination was done. Examination of vaginal smear revealed no gonococci. X-ray examination, September 26, 1928 (Fig. 9).

COMMENT

The definite history of a proven gonorrhoeal infection, followed immediately thereafter by involvement of the ankle and hip joints, reasonably establishes Case 1 as of gonorrhoeal origin. The radiograph shows a typical intrapelvic protrusion of the acetabulum.

Case 2 is of extreme interest. This patient developed an acute arthritis of the hip following influenza, and an x-ray examination at the time revealed practically complete obliteration of the joint space due to destruction of the cartilage, with undermining of the acetabulum. Although the influenza bacillus was not definitely identified as the causative agent it is at least permissible to assume that the condition followed an acute systemic infection. The destructive process as demonstrated by the x-ray manifested itself in its early stages by involvement of the

Fig. 7

Case 4. Bilateral involvement. Note irregularity of the inner surface of the left acetabulum, as well as of the head of the femur. Almost complete synostosis of the right sacro-iliac joint.

acetabulum chiefly, leaving the femoral head intact. Within eleven months of the acute infection, the maximum deformity had developed and was demonstrated roentgenologically. Even at this stage, it is evident from the roentgenogram (Fig. 5) that the maximum damage had occured, not in the femoral head, but in the acetabulum. This case records roentgenologically the onset of the disease and the final deformity.

The roentgenogram of Case 3 is that of a typical intrapelvic protrusion. This case has been previously reported. The interpretation given was that the vacuolated areas in the newly formed inner wall of the acetabulum are small abscesses, and that the dense bone produced is a reactive phenomenon, similar to that seen in cortical abscesses in long bones. The source of infection was probably the biliary tract.

The history of arthralgia over a period of years, as well as the roentgenological and physical evidences of a rheumatic process in the spine and hip joints, point to a common etiology with the lesions of the hips in Cases 4, 5, and 6. In these instances, the hip joints share in the process simply as a non-specific arthritis.

FIG. 8

Case 5. Bilateral involvement. Note complete [illegible] of both [illegible] joints with localized area of eburnation in the left [illegible]. [illegible] arthritis of the lumbar spine. Femoral heads intact. [illegible]

FIG. 9

Case 6. Bilateral involvement. Note eburnation of articular margins of bones of left sacro-iliac joint. Femoral heads intact. Joint spaces clearly defined.

DISCUSSION

In the review of the subject herein presented, it is evident that there is considerable speculation regarding the etiology of the lesion. Confusion regarding its origin appears to be due to attempts by various authors to consider it a disease entity, having as its origin a specific bacterium. We regard this view as fallacious. A careful perusal of the protocols establishes the fact that the condition may be produced by any process which involves essentially the acetabulum and leaves the femoral head intact. Stated otherwise, any disease resulting in a localized osteomalacia of the acetabulum can produce the deformity, providing the femoral head maintains its boring qualities. Most authors agree that theoretically this is possible. The destructive process, however, must not be too severe and must permit bone regeneration.

We have already seen that, of all the cases quoted in the literature, Schlagenhaufer's remains the only one in which the gonorrhoeal origin of the disease appears to have been established. To accept the findings in a single case as indisputable evidence proving any contention would obviously be extremely hazardous and contrary to scientific methods. There are many objections to this theory. No other observer has isolated the gonococcus from an involved hip. It is the experience of most orthopaedic surgeons that gonorrhoeal joints are acute, destructive, and often result in ankylosis or synostosis. The histories of cases of intrapelvic protrusion are those of a slowly developing and not severely acute progressive deformity. When gonorrhoeal ankylosis occurs, it is bony in character; whereas the fixation that occurs in an Otto pelvis appears to be

due to numerous small bone blocks within the joint: in other words no true ankylosis exists. While Schlagenhaufer admitted that intrapelvic protrusion of the acetabulum was rare in gonorrhoea, he attributed its infrequency to the effectual employment of therapeutic measures. While it is true that rest and traction might limit the deformity, its effect on subsequent ankylosis would be nil. How would one explain, then, the absence of more frequent intrapelvic protrusion in cases of established gonorrhoeal arthritis of the hip?

Similar objections can be stated for the pyogenic infections. In this instance, there is an acute onset, stormy course, and constitutional reaction. These organisms readily destroy articular cartilage, obliterate the joint space, and ultimately result in ankylosis. The Otto deformity progresses slowly and shows only moderate destruction of cartilage, but there is, as a rule, retention of the general contours of the articulation. In all our cases the femoral heads and the articular surfaces of the acetabula were still clearly visible, although the deformities were extreme. A subluxation of the hip is found occasionally during the acute stage of a pyogenic infection. The displacement, however, is usually lateral and external and not intrapelvic. Notwithstanding the frequency of such cases in our institution, intrapelvic protrusion in pyarthrosis is uncommon. Our Case 2, is of this type. Our explanation is that the infectious process is too virulent and disabling to permit of any regenerative effort. Destructive changes predominate and the process subsides either with moderate disability or else with ankylosis. Often in the pus infections, the process involves particularly the femoral head and results in its necrosis, and effectually prevents any migration of the acetabulum. According to Henschen's postulate, the boring capacity of the head must be retained in order to produce the protrusion. Hence, in this instance, the loss in the integrity of the head prevents the production of the deformity. It is important to remember, moreover, that rest in bed by itself would tend to prevent the deformity, in that it removes the thrust of the femur on an already weakened acetabulum.

On the other hand, the attenuated infections may, since they are not severely destructive, permit of bone regeneration in an acetabulum, the seat of a low-grade inflammatory process. In this instance, the initial disability would not be great: confinement in bed would be unnecessary; and, as a result, motion and weight-bearing would provide the mechanical conditions necessary for the production of the deformity.

Numerous true cases of intrapelvic protrusion have been reported in patients undoubtedly suffering from tuberculosis. On analyzing the basic process involved in tuberculous coxitis, one is prone to believe that conditions favoring intrapelvic protrusion are present. In tuberculosis, the infectious process burrowing under the acetabular cartilage results in pronounced osteomalacia. Muscular spasm, combined with flexion, adduction, and inversion of the extremity, would seem to favor the production of the deformity. Clinically, however, the picture is [illegible]

tuberculosis. The striking feature in all the cases is the history of a slowly progressing deformity in a patient usually beyond middle age at a time when tuberculous coxitis is uncommon. Roentgenologically, the absence of bone atrophy and the presence of bone production in the hip would seem to exclude it.

When Charcot's disease, Paget's disease, osteomalacia, and metastatic malignancy occur in the bones of the pelvis, they often result in intrapelvic protrusion of the acetabulum. In Charcot's disease we have the combination of osteomalacia associated with hyperostosis, whereas in osteitis deformans and neoplastic diseases of the pelvis, the resulting bone softening encourages the development of the deformity. We must recognize, however, that the *deformity here is but a local manifestation of a* general disease, and that, in Paget's disease and osteomalacia, the picture of an intrapelvic protrusion is complicated by the generalized bowing or deformities both of the pelvis and femora. In Charcot's disease, the protrusion of the acetabulum is accompanied by the extreme hyperostosis and fragmentation of the femora characteristic of this disease.

Eppinger's theory of a chondrodystrophy assumes that the three cartilaginous plates of the acetabulum remain unfused and are projected into the pelvis by the pressure of the head of the femur. In the known chondrodystrophies, this deformity had not been described. We would consequently have to ascribe the protrusion to an as yet unknown disease involving solely the cartilaginous plates of the acetabulum and resulting in its protrusion.

On the whole, it seems advisable to recognize two different classes of intrapelvic protrusion: (1) an acute type probably infectious in origin; (2) a chronic type occurring in the course of any disease, resulting in an osteomalacia of the hip joint.

(1). *If the infection or inflammation* has involved essentially or accidentally the acetabular surface of the hip joint, the femoral head remains intact and the protrusion quickly develops. If the infection is severe and involves the head of the femur and the acetabulum, there is necrosis of the head and bony ankylosis may result before the deformity occurs.

(2). The secondary type *may occur in polyarthritis and* in general osseous diseases,—such as syphilis, osteomalacia, and Paget's disease. In this instance, the hip lesion is but an incident in the general deformity.

Many of the cases presented evidence of an arthritic process elsewhere, commonly in the sacro-iliac joint and spine, and often in the knees, wrists, and elbows. In many instances, the patients had attacks of acute articular rheumatism which preceded by years the discovery of the hip lesion. Is it unreasonable to assume that herein lies the clue to the etiology? Is not the Otto pelvis an atypical but essentially non-specific arthritis of the hip joint? We must abandon our conception of the *specificity and individuality of this lesion of the hip joint.*

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ARTHROKATADYSIS OF THE HIP JOINT *

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In January, 1929, P. J. Verrall [1] of London reported a case in which the lesion presented a sinking-in of the acetabulum, resulting in limitation in movement of the hip joint. He suggested the name "Arthrokatadysis", meaning literally "subsidence of a joint", and suggested that it may be a localized osteomalacia. He drew attention to the fact that there was no narrowing of the pubic arch as seen in true osteomalacia.

We wish to present two cases which have come under our observation, which we believe belong in this group. From these cases we are unable to throw any further light on the etiology of this condition, and are presenting them in the hope that further reported cases may lead to some appreciation of the etiology of these lesions.

CASE 1. Mrs. T. H., female, married, white, housewife, thirty-seven years of age.

History: Fifteen years ago, following childbirth, she had a "milk-leg". Since that time she has had trouble with the hip joint on this side. In general has been quite well; has had two children since the onset of the present complaint. Pain is described as burning in type, located in the hip-joint area, has become progressively more severe since onset, and is less in the morning and worse toward evening. There has been progressive diminution in motion in this hip until, at present, there is practically no ability to adduct or abduct it. She has worn plaster casts, but gets the greatest relief from a walking caliper. She wears this when she has hard work to do.

Physical examination: Medium-sized, normal-appearing woman, weighing 148 pounds. The examination was negative except for the left leg, which showed atrophy (moderate) of the musculature about the hip, one-fourth inch shortening. The motions of the hip joint were free in flexion and extension, but there was no demonstrable abduction or adduction.

X-ray examination (Fig. 1): Anteroposterior stereoscopic views of hips show a sinking-in of the left acetabulum into the pelvis, with thinning of the acetabular floor. The head of the femur, enlarged, was thoroughly engaged in the center.

CASE 2. No. 2292, Miss E. J., forty-three years of age, white, single, American, occupation housekeeper. First seen March 29, 1929, at which time there was complaint of pain in the left hip joint.

History: Four years previous she had had pain in her left knee, which was diagnosed as rheumatism. Several teeth were removed, but without relief, and the condition became progressive. She was then confined to bed for five months, during which time she was free from pain, but, on returning to her feet, there was a recurrence of the old symptoms. Later a hip spica was used for immobilization, but, on removal and resumption of weight-bearing, the symptoms again reappeared. Her main complaint at the time of examination was pain in the left knee, thigh, and hip, on attempting to rise from a sitting position, but which was somewhat lessened by rotating the knee inward before arising. Patient denied any serious illnesses or injury, always had been well and strong. [illegible] have been normal and history was negative for any pathological findings.

Physical examination: Muscular woman; tall, erect, heavy frame, weighing [illegible] pounds, appeared in good health and well nourished. [illegible]

* This report of two cases of this unusual affection was [illegible] by Dr. Pomeranz (page 663). This is of special interest, [illegible] review of cases in the literature as presented by Dr. Pomeranz.

TUBERCULOSIS OF THE FIFTH LUMBAR VERTEBRA WITH SPINA BIFIDA OCCULTA. SPINAL FUSION AND CURE

Case Report

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Tuberculosis of the fifth lumbar is rarely seen, and the surgical cure of such a case with concomitant spina bifida occulta seems worthy of record. On account of the long duration of the illness and the general condition of the patient, operative treatment was advised although the boy was only ten years of age. Multiple bone-chip transplants, taken from the tibia, were employed to form two lateral struts because of the absence of spinous processes and laminae in the affected region. Fusion of the spine followed, with calcification of the anterior abscess, and the patient was ambulatory and apparently cured one year later. His condition has improved steadily to date, and now (nearly six years after operation) he is symptomless, has no disability, and the fusion has not interfered discernibly with his growth in height.

CASE HISTORY

Boy, aged ten. Family history was of no importance. Past history was negative except for measles, scarlet fever, and tonsillectomy two years before. The parents dated

Fig. 1

Tuberculous fifth lumbar vertebra before operation. Note deficient laminae of fifth lumbar and first two sacral segments, also shadow of anterior abscess.

Fig. 2

Lateral view of Fig. 1, showing destruction of body of fifth lumbar vertebra, slight anterior dislocation, and abscess.

FIG. 3

Same as Fig. 1, eleven months after spinal fusion with multiple bone-chip transplants.

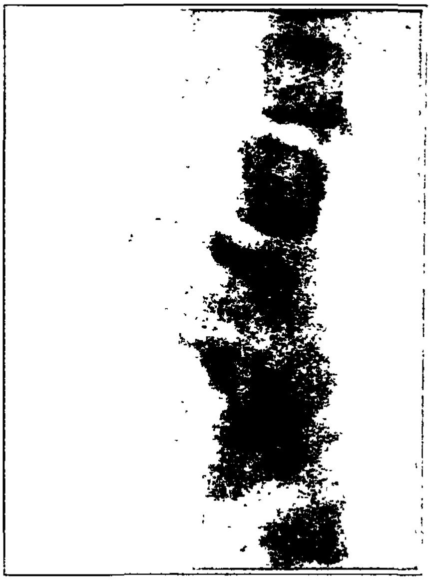

FIG. 4

Same as Fig. 2, eleven months after operation. Note new bone formation posteriorly.

FIG. 5

Same as Fig. 1, nearly six years after spinal fusion.

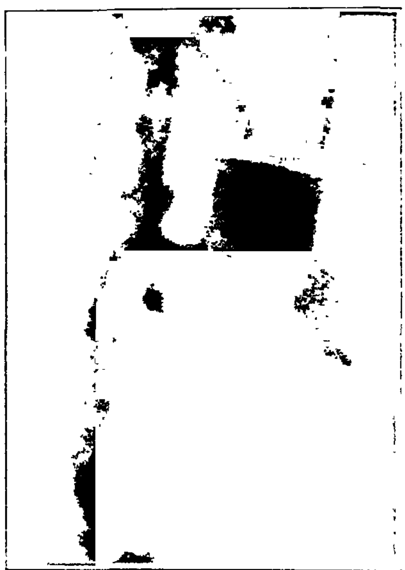

FIG. 6

Lateral view of Fig. 5, showing strong bony fusion, diminution in size of calcified abscess, and growth of vertebral bodies.

back the present illness to a fall eight years ago which was diagnosed "fracture." Subsequent back complaints were treated for rheumatism and scoliosis. A knuckle appeared in the back a few years ago. The patient was ambulatory, though complaining, until eight weeks ago when he took to his bed because of back pain, headache, and fever. He had not gained in weight recently.

On examination the patient was able to stand, but carried his back straight and inclined forward from the hips. Walking was slow and obviously painful. A definite knuckle was apparent at the level of the spinous process of the fourth lumbar vertebra. Marked muscle spasm prevented motion of the lumbar spine. No abscess was palpable, but extension of the hips was painful. The pulse was rapid and there was slight elevation of temperature.

X-rays revealed advanced destruction of the body of the fifth lumbar vertebra (Fig. 1) with lack of fusion of the laminae of the fifth lumbar vertebra and absence of the laminae of the first two sacral segments. The shadow of an anterior abscess was shown, together with slight anterior dislocation of the diseased vertebral body (Fig. 2).

At operation the muscles and periosteum were reflected laterally from the second lumbar vertebra to the mid-sacrum. *A fibrous membrane replaced the deficient laminae* of the first two sacral segments. The posterolateral articulations between the second, third, fourth, and fifth lumbar vertebrae and the sacrum were exposed and denuded of cartilage with a curet after the technique of Hibbs. Osteal shavings were removed from the remaining laminae of the lumbar vertebra and sacrum to expose raw bone. Many bone-chip transplants were then removed from the subcutaneous portion of the tibia and added to the above mass of shavings and chips so as to form two lateral struts from sacrum to the lumbar spine. The wound was closed in the usual manner.

No fixation dressings except pillows were employed until the stitches were removed on the twelfth postoperative day. Plaster-of-Paris shells were then made and the patient discharged home for heliotherapy and general antituberculous régime. The convalescence was entirely uneventful. New shells were made in four months and the boy was allowed to be ambulatory in a brace eleven months after operation (Figs. 3 and 4).

The patient has improved steadily to date. He has grown apparently normally and presents an excellent physique. His lumbar spine is solidly fused and causes him no disability though he is doing heavy farm work.

REDUCING DIET IN ORTHOPAEDIC SURGERY *

BY EMIL S. GEIST, M.D., MINNEAPOLIS, MINNESOTA

Orthopaedic Surgery is essentially the surgery of the connective tissues.

Today we deal with the lowliest type of connective tissue,—fat. We will consider fat as it affects weight-bearing in orthopaedic patients. Fortunately, as a rule, it is the most easily controlled tissue in the body.

"*Weight-Bearing*".—Up to now orthopaedic surgery has focused its attention on the latter half of this word. Our efforts have been largely concentrated on the "bearing"—the portative—qualities of the spine and legs. The various stabilizing and corrective operations, the large assortment of casts and splints, and the voluminous studies on posture and balance point to this.

Is it possible that we do not pay sufficient attention to the first half of the above word? Do we neglect the subject of weight in our patients? If not, then we have written mighty little about it. Most textbooks are absolutely silent; a few make allusions. In 1931 I read a paper on "Diet and Orthopaedic Surgery" before the combined State Medical Associations of the Dakotas. As far as I know, it is the first article on this trite subject. No doubt our Program Committee had this in mind when it asked me to present a similar subject today.

Fat causes orthopaedic trouble in two ways:

(*a*). By its presence in excess within a joint,—as Hoffa fat knee (numerically a small group).

(*b*). By contributing to excessive body weight and thus throwing pathological strain on sick, maimed, and weakened weight-bearing organs (numerically a very large group).

The Hoffa Fat Knee.—Proper weight-reducing diet has, in our hands, caused excessive intra-articular fat to disappear. This often obviates operative surgery as advised and practised today. We have had nine cases in which relief was obtained and operation avoided. The most characteristic case may be cited in a few words:

CASE REPORT

H. S., female, twenty-five years old, a teacher, was sister of a prominent internist.

Diagnosis: Bilateral "Hoffa fat knee". Was unable to walk over one and a half hours daily (the balance of the day having been spent in a chair).

Chief symptoms: Pain on use; mild swelling; indefinite locking of both knees.

Reduction of weight (twenty-five pounds) resulted in absorption of excessive intra-articular fat. Now is well, attends to her duties, and plays tennis expertly. (This observation dates back to 1912.)

* Read before the Annual Meeting of the American Orthopaedic Association, at Toronto, Canada, June 17, 1932.

Two homely incidents again called my attention to this subject some ten years ago:

(*a*). The gun, which actually weighed eight pounds, but seemed fifty pounds heavy at the end of the day's hunting.

(*b*). The immense annual bodily relief felt on changing from the heavy "winter" fur overcoat to the topcoat of spring.

From the foregoing facts I drew two conclusions and have acted upon them since:

(*a*). If prolonged excessive weight-bearing will tire normal individuals, what will it not do to defective human carrying apparatus?

(*b*). The actual amount of excessive weight need not be large,—often ten or fifteen extra pounds may cause trouble and their removal might give relief.

The Spine.—We believe that excessive weight in itself may be the cause of many backaches. We always attempt to bring the weight to normal (for height and age) in the following conditions: lumbo-sacral strain, spondylolisthesis, round shoulders, and postural defects. In adult scoliosis which is causing pain, this method has spared several of our patients a fusion operation.

The Hip.—A painful, senile arthritic hip in a heavy man often becomes comfortable from weight reduction alone. Some of our most grateful patients belong to this class. We have also successfully availed ourselves of this method in old unreduced congenital bilateral hip dislocations and in cases of old Legg-Perthes' disease and coxa plana which were painful. The underlying pathology is, of course, not changed at all, but the superincumbent overload is removed. If pain persists, we can always operate on the joint later. Our patient will have become a much better surgical risk by the weight reduction.

The Knee.—Chronic unilateral and bilateral arthritis from whatever cause in the later adult years offers a fruitful field. Occasionally weight reduction alone totally removes all subjective symptoms. While we, of course, as a rule avail ourselves of other therapeutic measures (chiefly physiotherapy and splinting), we have a small series of cases in which the desired relief of knee symptoms was obtained by the sole use of the restricted diet.

The Foot.—We find that the most frequent use we make of this method is in foot conditions (weak foot and metatarsalgia). It is a valuable and indispensable adjunct of treatment even if weight excess seems small (ten to fifteen pounds). We have arrived at a point where we refuse further treatment if the patient does not cooperate. We feel that proper shoes, arches, and exercises do not have a fair chance if the overload is permitted to remain.

Infantile Paralysis.—Excess weight should be prevented in this chronic condition. If it is present, it should be gotten rid of. Manifestly the atrophied legs and returning muscles should not be required to function under more than the physiological load. It is probable that not

the least of the benefits of the swimming pool is that it stimulates metabolism and thus helps to keep the patient's weight within reasonable limits.

Fractures—(three considerations):

(*a*). The obese are poor fracture risks when viewed from any angle. It is good fracture prophylaxis for all of us to remain thin and supple—(Much could be made of this theme).

(*b*). Fresh fractures. In heavy, fat, adult individuals, we begin a reducing diet from the onset of treatment. We believe it to be good therapy not to demand too much of the recently healed weight-bearing bone.

(*c*). The old malunited fracture of hip, knee, ankle, or foot often becomes comfortable on removal of the overload. In our practice numerous patients have thus avoided operative interventions. (This is especially true in people over fifty.)

Nothing will be said about the method of weight reduction. This is a rather long story which has been well told by many There are many good books on the subject. We have never used thyroid extract or any other drug as an aid to weight reduction. We fear it. We never allow a patient to lose more than two or three pounds per week. Many patients become over eager to lose weight rapidly. This enthusiasm needs checking. Other patients are obstreperous or lazy. No results are to be expected among them. When the desired weight loss exceeds fifty pounds, we call on the internist to act as referee in the struggle between the patient and his own fat.

CONCLUSIONS

(*a*). Consideration of a proper reducing diet has become, in our work, of daily necessity and occurrence and of practical value.

(*b*). A chronically painful joint or series of joints of the spine or lower extremity often ceases to be troublesome in an individual who has been overweight and who, by means of a reducing diet, has brought his weight to normal.

(*c*). The amount of overweight need not be large,—occasionally the removal of ten or fifteen pounds is enough to spell the difference between comfort or pain in a given case.

(*d*). This method in proper cases is an adjunct to other forms of treatment used in orthopaedic surgery.

REPORT OF A CASE OF UNUSUAL INJURY TO THE FOREARM

BY PENELOPE SHERWOOD, M.D., NEWBURGH, N. Y.

The following case is reported because of its unusual character.

Patient H. McN., aged eighteen, white, male— was referred to the writer September 9, 1930, by Dr. C. E. Fallon of Newburgh, New York.

About eight weeks previous, i.e., in July, 1930, the patient, while employed in a fabrikoid factory, caught his left arm in a roll of cloth as it was being wound tightly on rollers, the arm being drawn in up to the elbow. No acute pain was experienced at the time. The patient was seen immediately by the company physician, Dr. Fallon. The arm presented a marked degree of posterior bowing of both radius and ulna, together with fixation in position of supination, a condition which had not been present two days previously when Dr. Fallon had given the patient the physical examination required before employment.

An x-ray (Figs. 1 and 2) revealed a partial epiphyseal separation of the left radius and ulna with no displacement, with a disturbance of the relations of radius and ulna at the wrist joint, the distal end of the ulna being more nearly on the level with that of the radius than is found normally.

The arm was splinted for three weeks, then the patient resumed work for one week but had to desist on account of pain in wrist and forearm. There had been no improvement under daily massage and baking, and the arm was still in supination.

Physical examination on September 9, 1930, gave the following findings:

FIG. 1

Left radius and ulna, August 1, 1930, following injury. Note the abnormal amount of bowing of the bones as compared with that in the right arm.

Physical examination was negative except for the left forearm which showed:

Distinct bowing of both bones (convexity dorsal).

Elbow, wrist, and fingers showed full range of motion.

Strength of grip in left hand only one-third that of right.

All muscle groups apparently active.

The forearm was in full supination with less than five degrees' active pronation.

Passive pronation could be accomplished to about twenty-five per cent. of the normal range.

Further attempt to pronate caused pain in wrist, on palmar surface.

There was no swelling, but patient stated that, on flexing the fingers, the hand felt "swollen".

Diagnosis was made of traumatic deformity of radius and ulna. X-ray (Fig. 3) showed healing of epiphyseal injury, with no bony block to pronation, but with the marked bowing of the radius and ulna.

TREATMENT

Two weeks of baking, massage, and vigorous passive and active motion accomplished little in regard to active pronation, and there was an increase in throbbing pain in arm and hand.

October 22, 1930, an osteotomy of the left radius and ulna was performed through two incisions at the apex of the bow. On reduction of the bowing, the arm could be pronated easily beyond neutral. After closure of the wound, a cast was applied from the axilla to the base of the fingers, with the forearm in a position half-way between neutral and full pronation. Postoperative x-ray (Fig. 4) showed the osteotomy with the fragments in good apposition, a restoration of the normal curve of the radius and ulna, as well as of the relation of the two bones at the wrist joint. The bone was extremely hard, which makes it surprising that so much bowing could have occurred without fracture.

Convalescence was uneventful aside from a somewhat slow formation of sufficient callus. The stitches were removed after ten days, and at three weeks the cast was bivalved and light massage and active motion begun.

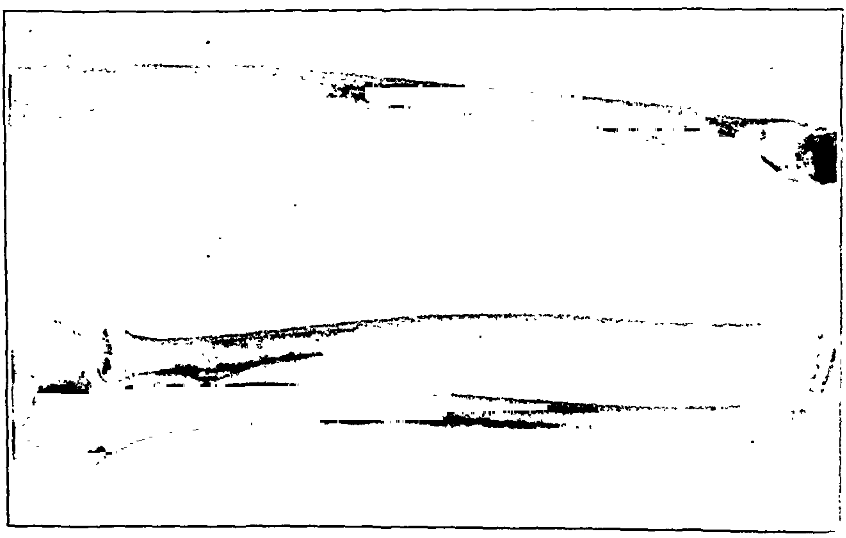

FIG. 2

Right radius and ulna, October 22, 1930.

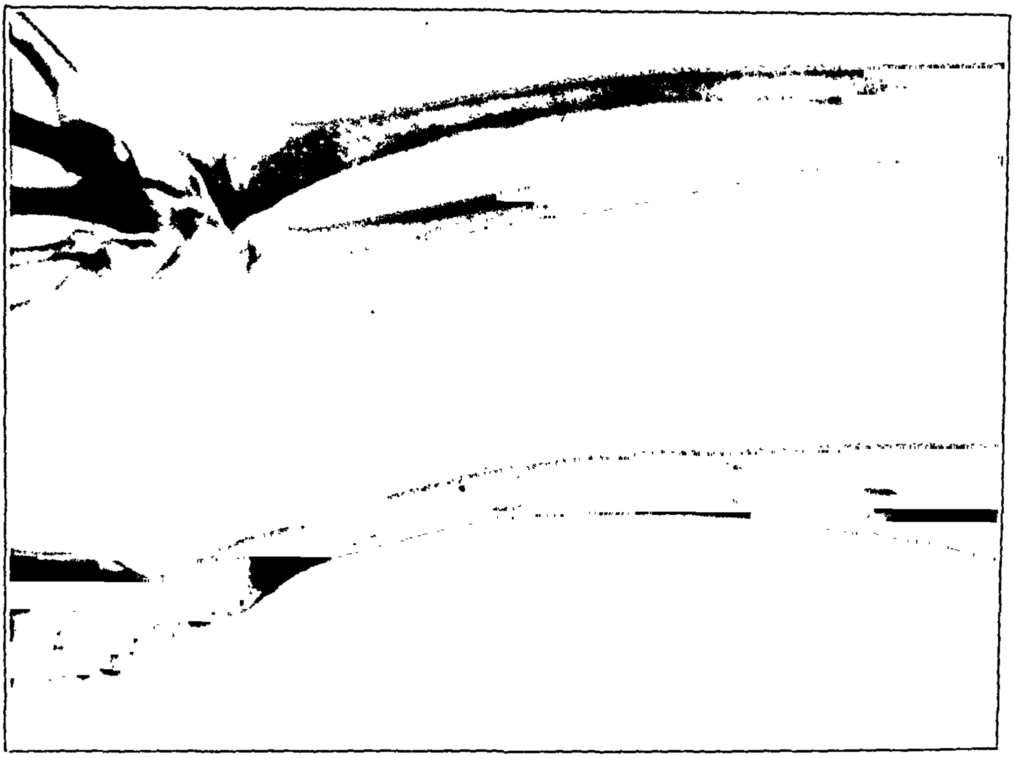

FIG. 3
Left radius and ulna, October 22, 1930, just before osteotomy.

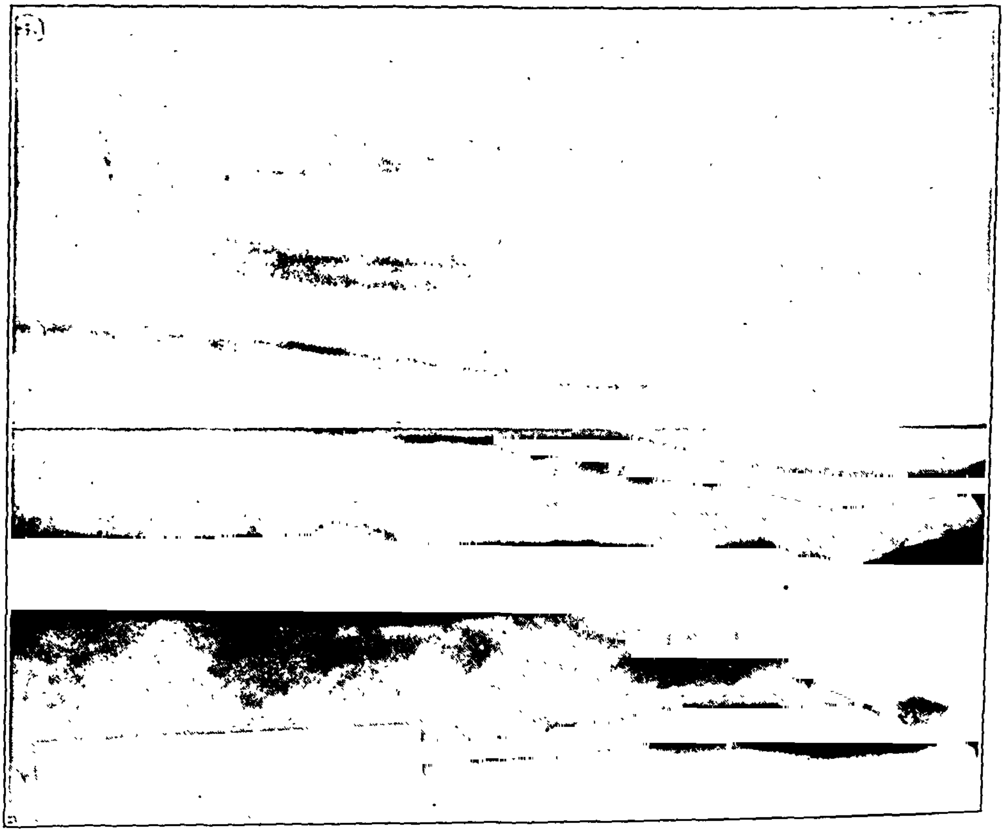

Fig. 4
Left radius and ulna, October 23, 1930, showing correction of deformity.

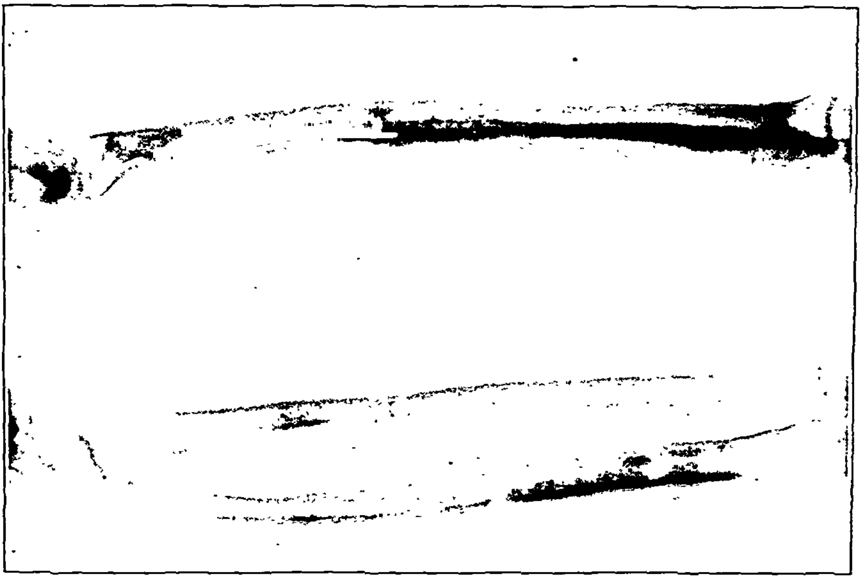

FIG. 5
Left radius and ulna, January 4, 1931, three months postoperative.

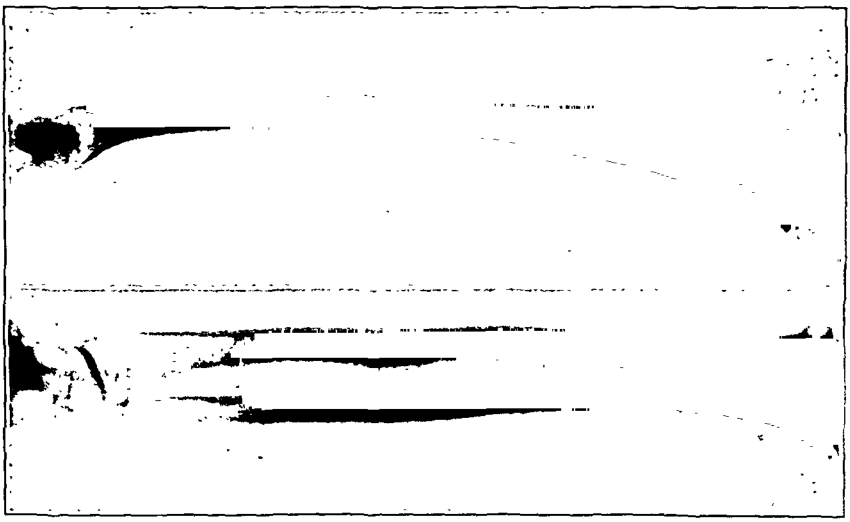

FIG. 6
Left radius and ulna, May 20, 1931, seven months postoperative.

Twelve weeks after operation, all support was removed. By March 14, 1931, (five months postoperative), the x-ray showed complete healing of the osteotomy, and the arm showed: full pronation and supination, no abnormal bowing, no pain nor tenderness; numbness in thumb which followed operation was practically gone; strength in grip of hand was ninety per cent. normal.

The final examination on May 16, 1931, showed the same findings as in March, except for an increase in the strength of the hand to normal.

SECTION OF THE FLEXOR TENDONS OF THE MIDDLE FINGER OF THE LEFT HAND THROUGH A PALMAR WOUND. PRIMARY SUTURE AND CURE

BY ANTHONY ANDREASEN, M.R.C.S., KINGSTON HILL, ENGLAND

Madame X was admitted to the hospital July 27, 1931, suffering from a palmar wound, following a fall upon a bottle. She had been to her own doctor who had done his best to clean the wound and had sent her to the hospital.

On examination four hours after the injury, a contused jagged wound three centimeters long was found, extending from the inferior border of the annular ligament of the wrist across the palm and the fold formed by opposition of the thumb. Flexion of the middle finger was impossible. No nerve lesion could be demonstrated. Hemorrhage had been abundant but had stopped. A diagnosis of section of the deep and superficial flexor tendons of the middle finger alone was made. Infection of the wound was, of course, almost certain in view of the first effort to clean the wound. However, immediate intervention was decided upon.

Morphin was administered to the patient. The arm was then raised above the level of the shoulder and an Esmarch bandage applied from the elbow down towards the wrist in such a way as to make the flexor tendons come down towards their distal severed extremities.

Anaesthesia was produced by an injection of ten cubic centimeters of five-tenths per cent. novocain around the median and ulnar nerves at the level of the radial and ulnar styloid processes, and was completed by a ring of subcutaneous injection around the wrist at the same level.

Disinfection of the wound was then carefully carried out,—*i.e.*, block resection of the contused edges and enlargement of the wound in its long axis to give more space in which to work. The superficial palmar arch was then displayed and sectioned between double ligatures. The two extremities of the superficial flexor tendon were easily recognized, but the ends of the deep flexor were located with difficulty, owing to the marked involvement of the lumbricales of the second and third spaces. As these were torn and contused, they were resected as high up as possible and the greater part of them removed. When the ends of the deep flexor were finally brought into view, their mangled condition required removal of nearly five-tenths centimeter of each.

The tendon suture was performed with No. 0 forty-day chromic gut. Two separate sutures of catgut united the subaponeurotic cellular tissue. The palmar aponeurosis was sutured with three fine catgut stitches and the skin drawn together gently with fine fishing gut, the whole wound being closed without drainage.

The dressing applied consisted of a large piece of roll gauze in the palm with quantities of wool over it, and a bandage. A dorsal plaster-of-Paris frame was then applied in order to keep the fingers and wrist in flexion.

After the operation there was no pain and no rise of temperature above 99 degrees. The dressing was renewed on the eighth day and the stitches removed. The suture line was slightly reddened. On the fourteenth day the posterior plaster gutter was removed and the wound looked firm and healthy; a new dressing was applied. Gentle and progressive movements were started and the patient left the hospital in very good condition.

At present her hand shows: flexion of the first and second phalanges of the middle finger, normal; flexion of the third phalanx, slightly limited; the lateral movements of the fingers, normal; palmar scar, soft and non-adherent; no loss of sensibility or other evidence of nerve lesion. Muscular power is normal.

The patient now having full use of her hand, it seemed that a note of the case and the reason for resection of the lumbricales would perhaps

be of interest, since it is to that procedure that success in the case is attributed.

This case report is of interest for the following reasons:

1. Some authors state that suture should be primary as in the above case; others prefer secondary suture. This case would seem to uphold the teaching of the first group.
2. The way in which the Esmarch bandage was applied is well enough known to avoid need of comment.
3. The anaesthesia is of importance. The nerve-block anaesthesia employed is easy to use and is extremely efficient. It is essential to allow ten to fifteen minutes to secure complete anaesthesia.
4. The lumbricales of the second and third spaces were resected. Most authors mention injury of the lumbricales associated with tendon lesions, and their importance in the propagation of infection, but none give any opinions on the matter of resection. In view, therefore, of the contused state of the muscles, and the fact that their cicatrization would only tend to fix the tendons to the surrounding structures, resection was performed. This procedure also gave more room in which to work.

Bloch and Tailhefer suggest resection of the superficial flexor tendons to allow suture of the deep flexors, but so much damage seems unnecessary when simple resection of the lumbricales gives even more room.

The objections one might raise to the procedure are:

1. That it is impossible to resect the lumbricales without involving the synovial sheaths of the tendons.
2. That the lumbricales are important in the physiology of the hand.

American surgeons would preserve the serous sheaths at all costs, while Leriche contests that it is necessary to extirpate them. The author believes that, as in the case of all traumatized serous membranes, they will, if left, only cause adhesions and bands, and so hinder a complete recovery.

In reply to the second objection, the lumbricales are not in the true sense autonomic muscles; they have no true long insertion and in function they only reenforce the interosseus muscles.

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A CASE OF HEMANGIECTATIC HEMIHYPERTROPHY WITH SUBJECTIVE SYMPTOMS OF SACRO-ILIAC DISTURBANCE DUE TO ABNORMAL BONY-DEVELOPMENT

BY J. E. M. THOMSON, A.B., M.D., LINCOLN, NEBRASKA

Though anomalies of development are rare, particularly those in which one or more of the extremities develops out of proportion to the others, they cause distressing and unfortunate disabling phenomena that manifest themselves not only in their determent of function but also as an unsightly stigma upon the patient, often contributing to mental manifestations of abnormal nature.

Wakefield[1], in 1926, in reporting a case of terminal hypertrophy of the left shoulder girdle, arm, and hand, with naevus and varicose veins, gives a very satisfactory historical résumé of the cases in the literature. The earliest case he found was one reported by Wagner[2] in Germany in 1887; Osler[3] found twelve cases in a review of all the literature up to 1889. However, in 1897, Le Blanc[4] collected seventy-eight cases. Gesell[5] collected forty cases in 1921. From these various series Wakefield accounted for one hundred and ninety-five cases, forty-four of which were total hemihypertrophies.

Since Wakefield's article at least ten other cases have been reported in the literature. These conditions appear under various names but are usually associated with increased blood supply and the hypertrophied extremities or parts of the body, with various degrees of increased pigmentation and reddening of the entire or part of the extremity or trunk.

Among the more recent cases is that of a child, aged seven, recorded by Paterson and Wyllie[6], with increased growth of the right leg and with surface temperature apparently higher than the left; pigmentation and dilated blood vessels present about the knee and shin. Their opinion was that the abnormal growth could be explained by the increased vascularity at least at the knee joint and the growing end of the tibia and fibula.

Susman and McCredie[7] reported a case of a girl, fifteen years of age, whose enlargement of the arm was of only six months' duration, and they gave to this condition the term "haemangiectatic hypertrophy", and thought perhaps the condition could be accounted for by an old venous thrombosis.

Beatty[8] reports a girl with swelling of the veins of the left arm and increased length of the limb with evidence of not only dilated vessels and increased temperature but cutaneous angiomata.

Harris and Wright[9] showed a boy, aged ten, whose history dated back to a recognition of the hypertrophy of the right leg in early life. The pigmented patch on his leg had recently ulcerated. There was four and one-half centimeters of difference in the length of the extremities. This

led them to experimental work to determine whether increase in blood supply was totally responsible for an increase in the length of the bone. They destroyed the sympathetic innervation to the forelimbs of a group of kittens, thereby increasing the blood supply to the forward extremities. Rather confusing results were obtained, but their deductions led them to believe that the increased blood supply, due to liberating the vasoconstrictions, in itself would not result in hypertrophy and increase in bony length of the extremities.

Cannon[16] and others at Harvard performed similar experiments and found no increase in growth of length of the limb after unilateral sympathectomies. One explanation is that perhaps the vessels supplying nutrition to bones have no opportunity to dilate within their bony canals, even when the sympathetic vasoconstrictors are released, thereby not permitting increase of blood supply to the bone structure About the same status of opinion exists in regard to the lack of dilatation of arteriosclerosis vessels after release of the vasoconstrictor mechanism. For under such circumstances the hardening changes in the vessel walls make dilatation impossible.

It has long been recognized that a chronic passive congestion, when it is due to a chronic inflammatory process, particularly in the region of the knee, will cause an increased growth in length of the extremity. With such a process there is an increase in vascular supply, due to an actual increase in blood vessels within the inflammatory lesion. It would, therefore, seem reasonable to assume that, in those congenital cases of hemihypertrophy with increase in length of an extremity, there must be an increase in number of blood vessels within the bones involved, in a relative proportion to the evidence of increase in the peripheral blood supply, and evidence of hemangiomata.

The case of Susman and McCredie, with the history of an acquired hypertrophy as the result of an attack of thrombosis, would substantiate this explanation, as the hypertrophy directly followed an inflammatory process with increase of vascular tissue.

The writer wishes to add another case to those reported in the literature.

A young woman, aged thirty-three, was first seen at our clinic August 3, 1920. She came in complaining of bilateral hallux valgus and flat feet, sacro-iliac pain, and an increase in the length of the left lower extremity. At that time her bunions were removed and she was given a sacro-iliac brace to wear. The possibility of shortening the left leg was discussed. She made an uneventful recovery from her bunion operation, but after the period of hospitalization again complained of pain in the lower part of the back. Finally a diagnosis of sacro-iliac arthritis was tentatively made and treatment instituted in that direction. Temporary relief was obtained by a brace. She disappeared from the clinic and, in February 1923, she came back directly under the writer's care on account of painful pronated feet and low back pain.

A careful history brought out the fact that she had had an extensive erysipelas extending over the trunk at the age of nine, and a similar attack three years later. Since her last visit she had drifted from one to another of the leading (and otherwise considered) clinics throughout the country, receiving all manner of treatment and advice, without getting relief from the pain in the sacro-iliac region. The left lower extremity

was almost two inches longer than the right. The circumference of the left thigh was two and one-half inches larger than the right, and the left leg, one and one-half inches larger than the right. The left foot was extremely pronated and apparently there was very marked muscular weakness. It seemed evident that, if the left lower extremity were shortened to equal the right, the correction of her posture would very likely relieve the sacro-iliac strain from which she continuously suffered. Such radical surgery she would not consider. As an immediate palliative procedure the heel of the left side was lowered, the heel raised on the right side, thereby compensating to a certain extent for the difference in length of the extremities, and corrective apparatus for the pronation was applied to the shoes. Finally, in October, 1924, the femur was shortened and the length of the legs equalized. During the year following she was kept under observation, but continuously complained of the low back pain in the left side. Again she disappeared to visit more clinics and to receive more treatments of various kinds; finally she reappeared in December, 1930, with the report of having suffered more or less continuously with pain in the left sacro-iliac joint.

FIG. 1

The left side of the entire body (head, neck and lower arm excepted) is a dark wine color. The left thigh and leg are distinctly larger than the right. The left thigh is shorter and the knee higher than the right, due to operative shortening of the extremity. The left arm is longer and larger than the right.

More x-rays were taken. There was no evidence of sacro-iliac disease or other abnormality not noted in previous examinations. These x-rays showed an unusual bony development of the left ilium, a deeper, larger, more rounded left pelvic outlet; the head, neck and shaft of the left femur were of virtually the same diameter. The mid-shaft showed healed evidence of the shortening operation. The photographic illustration of her body showed the generalized wine-red color of the pigmentation on the left side of the body which extended from the neck to the toes. It seemed to absolutely bisect the trunk, fading out in the upper part of the upper extremity. The legs were of about equal length but the left leg was considerably larger in circumference than the right, about two and a half inches at the thigh, and one and one-half inches at the calf. The left upper extremity was one and one-fourth inches longer than the right. The left arm was one-half inch larger than the right; the forearms were equal. The feet apparently had fairly well compensated for their deficiency and caused her little or no difficulty when proper shoes were worn. She had a rather moody disposition; one might consider her peculiar and eccentric, but no definite mental derangement was exhibited. Probably the recognition of her unilateral development and pigmentation were responsible for these eccentricities. The only explanation of the extreme discomfort she complained of was the possibility that, since an inequality in length of the extremities had been corrected, there was still an inequality in the development of the sacro-iliac joints. In other words, the ilium articulation might have increased in proportion beyond that of the sacrum, or the inequality of the two sides of the pelvis had instituted an incompensable postural asymmetry responsible for unusual movement in the left sacro-iliac joint, causing the painful symptoms complained of.

The patient was advised of the possibilities offered in a sacro-iliac fusion for relief of her discomfort. She readily acquiesced and as a last resort, on December 17, 1930, the

operation was performed after the method described by Smith-Petersen. She was placed in a double plaster-of-Paris spica cast which was removed at the end of six weeks and a sacro-iliac belt was applied. She was allowed to leave the hospital at the end of nine weeks with little or no discomfort or pain. Her convalescence has been entirely uneventful. The pain and discomfort so long complained of have entirely disappeared. thereby substantiating the assumption that a pelvic unbalance, with abnormal left sacro-iliac function, was responsible for her symptoms.

The symptoms and physical manifestations of hemangiectatic hemihypertrophy of this case are essentially different from most of those reported in that there was such pronounced disability and discomfort, due to the increase in length of the left lower extremity and also to abnormal development of the left side of the pelvis, principally of the ilium.

This unusual case is reported because of the interesting objective physical phenomena exhibited and the particularly aggravating, long-standing, painful symptoms of low back pain that did not respond to equalization of length of the extremities, but did respond to rest in bed and partially to the wearing of a pelvic brace, only to reappear with activity of the patient or the laying aside of the brace. Later the brace lost much of its effectiveness, and ultimately a fusion of the left sacro-iliac joint brought relief of symptoms.

Fig. 2

X-ray of pelvis. There is a very much larger and abnormally developed ilium on the left. The left pelvic outlet is distinctly different from the right and has a more rounded appearance. The head, neck, and diameter of the femora are about equal.

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OSTEOGENIC SARCOMA IN CHILD OF THREE YEARS

BY A. L. CRAIG, M.D., F.A.C.S., HONOLULU, T. H.

Shriners' Hospital, Honolulu

The following case is presented as interesting from the standpoint of diagnosis as well as treatment. The report emphasizes the necessity of tissue section even in a child of three years.

History. E. N., an Hawaiian, aged three years. A small Hawaiian girl, very anaemic and appearing acutely ill, entered the out-patient clinic on the morning of May 4, 1931.

The general physical examination was essentially negative except for a large fungating mass over the anterior aspect of the right tibia. When the dressing was removed, the wound bled very freely and it was necessary to use pressure bandage to control hemorrhage.

Blood tests showed:

White blood count—6,700.

Hemoglobin—45 per cent.

Red blood count—3,685,000.

Wassermann and Kahn tests were made and later reported as negative.

Family history. Father, aged thirty-eight, is living and well: mother, dead; three brothers, aged five, six, and seven, and a sister, aged two, are living and well.

Clinical history. This child was admitted to the Kauikiolani Children's Hospital on November 24, 1930, with a history of slight pain and tenderness over the tibial tuberosity on the right leg. Temperature 99.6 degrees. White blood count 8,600. X-rays showed a destructive process involving the upper end of the tibia on the right side.

On November 24, 1930, the area was opened and curetted. Cultures taken at the

FIG. 1

MAY 4, 1931.

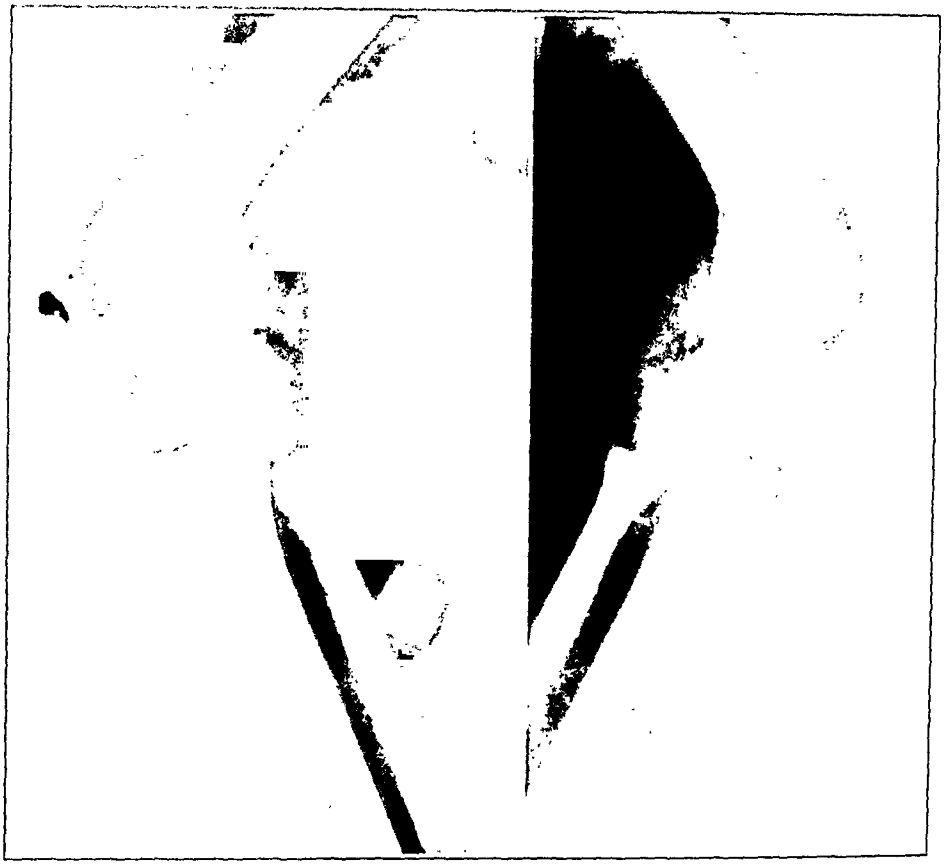

Fig. 2
November 24, 1930.

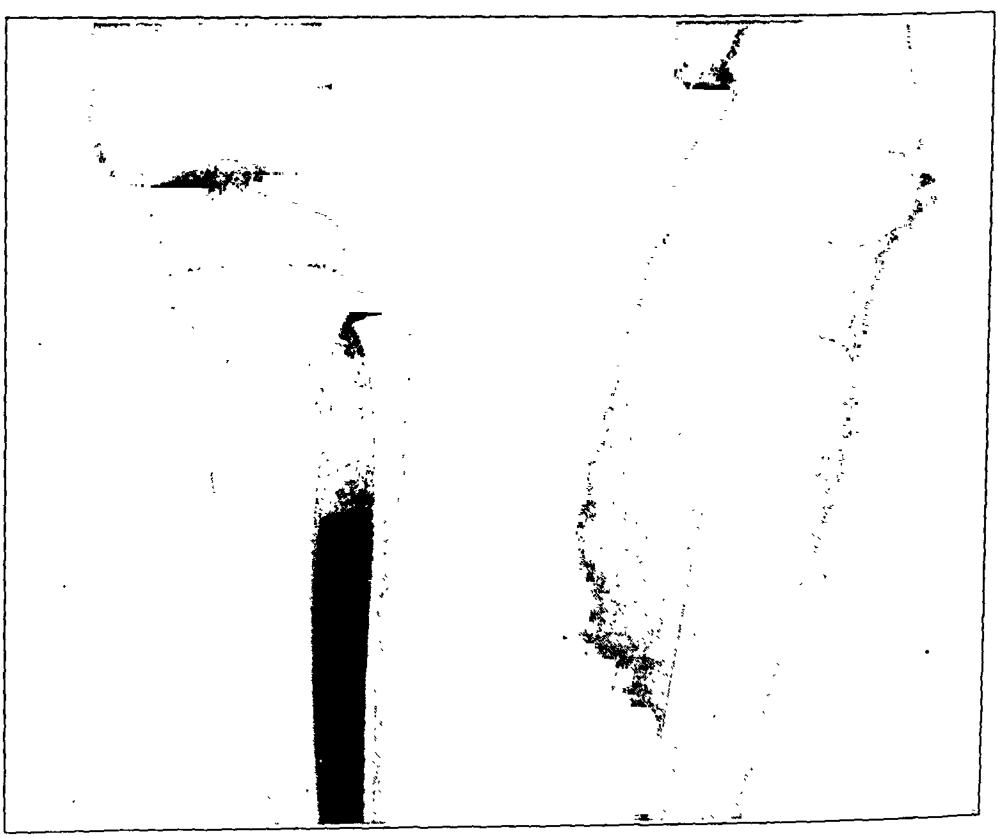

Fig. 3
December 1, 1930.

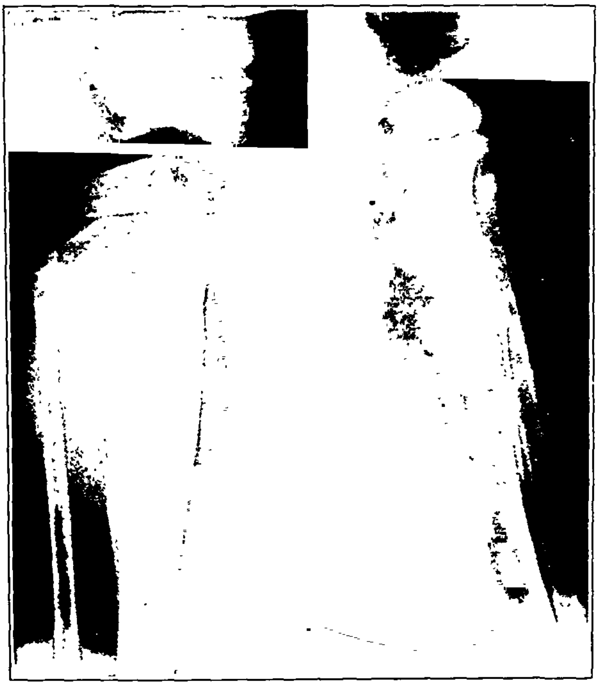

Fig. 4
May 4, 1931.

Fig. 5
May 12, 1931.

time of the operation were negative. Child was discharged from the hospital on December 3, 1930.

On February 3, 1931, she was again admitted to the Children's Hospital. Temperature was 100.2 degrees and white blood count was 8,700. X-rays taken showed some extension of the process. On February 4, 1931, the area was again curetted out. Cultures taken at the time of this operation were also negative.

Fig. 6
June 2, 1931.

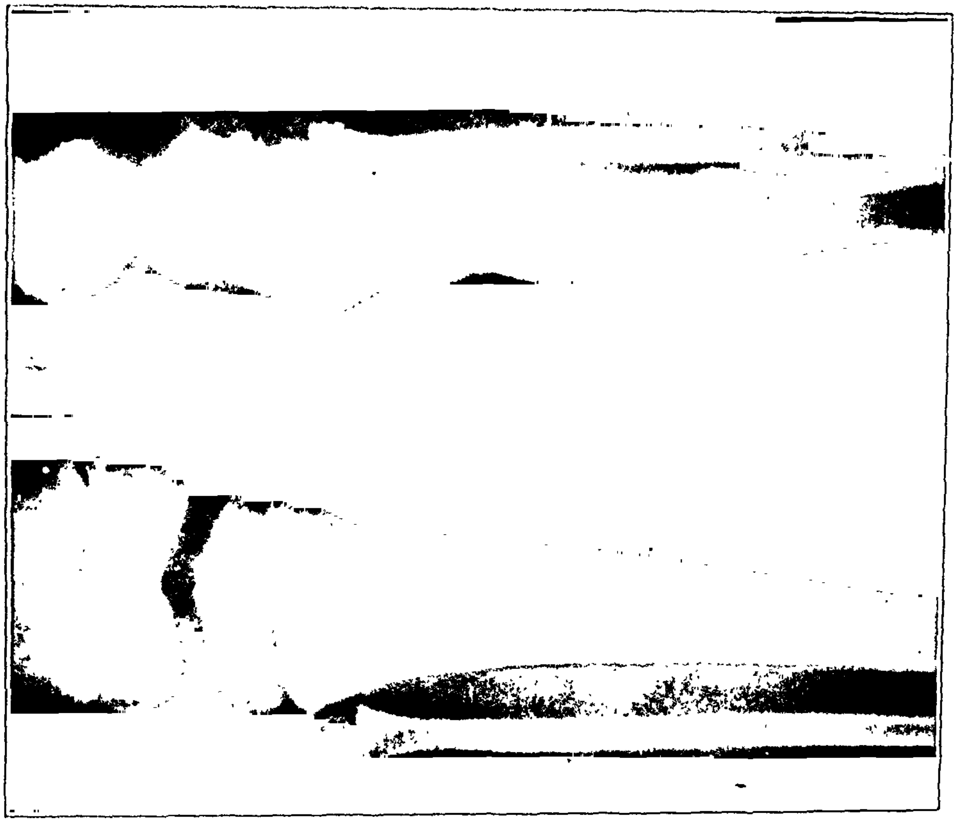

FIG. 8
NOVEMBER 15, 1931.

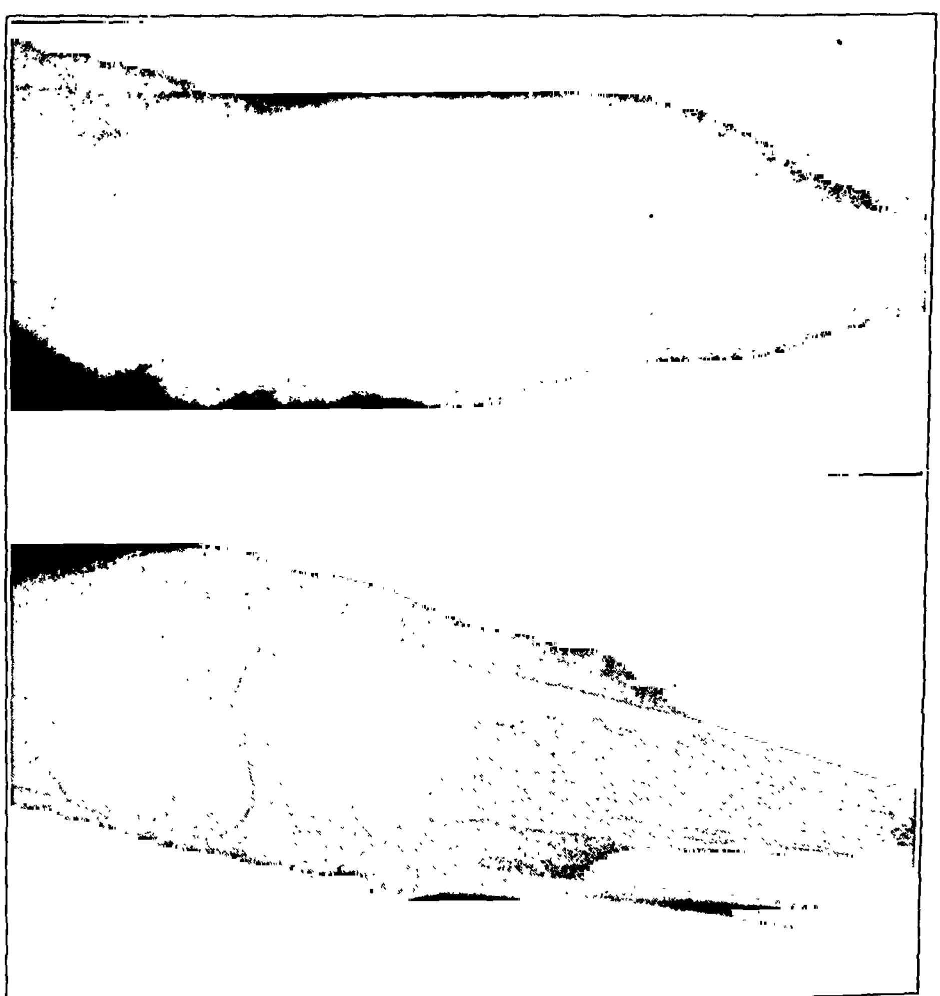

FIG. 7
JUNE 24, 1931.

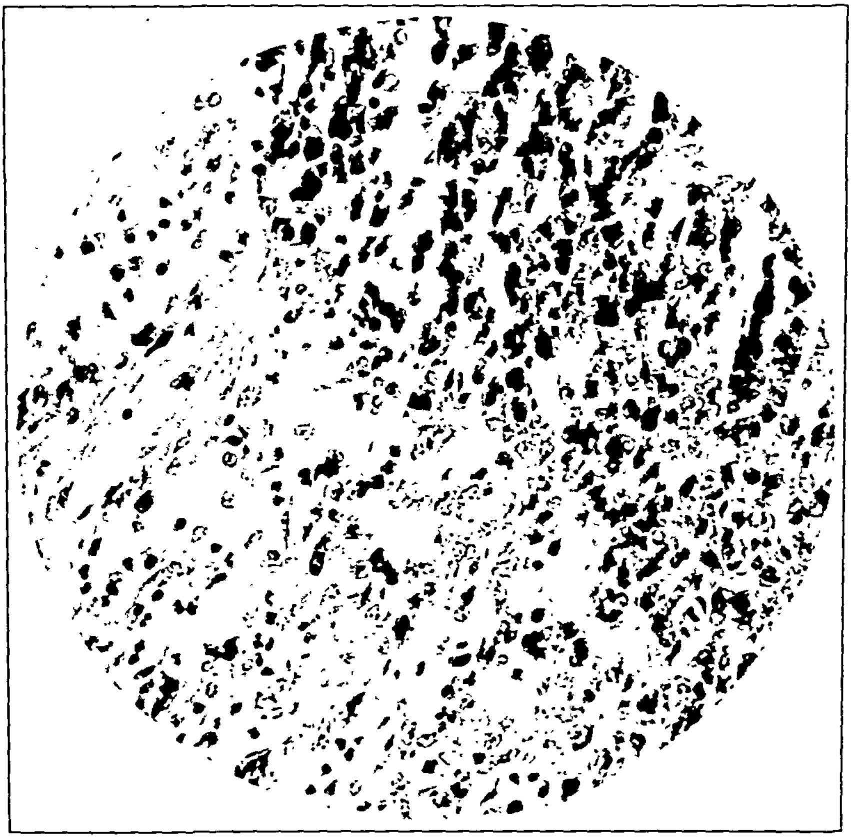

Fig. 9

The child was admitted to the Shriners' Hospital on May 4, 1931, for observation and biopsy.

On May 10, 1931, the section was returned with a diagnosis of osteogenic sarcoma.

On May 21, 1931, 2,000 milligram-hours of radium was applied to the wound. In a few days, the hemorrhage had subsided and the mass was very much smaller.

The child was discharged to her home, but reported back on June 2, 1931, when 2,000 milligram-hours of radium was again applied and, on July 2, 1931, when 3,000 milligram-hours was applied.

Present condition. At the present time the child has gained ten pounds, the mass has entirely healed, and x-rays of the chest and other long bones are negative. It is yet too early to draw any conclusions, but at present the child has no external manifestation or x-ray evidence of an extension of the growth. She is reporting at regular intervals to the clinic, and will continue to do so during the next two years.

AN ANALYSIS OF PRIVATE ORTHOPAEDIC PRACTICE

BY RICHMOND STEPHENS, M.D., NEW YORK, N. Y.

The following statistical report has been prepared to answer questions often propounded by surgeons who are considering entering the field of orthopaedic surgery. It is based on 400 clinical records taken from alphabetically filed closed cases and not any picked group. These cases were all in a private practice in a city of approximately 50,000 population, with about eighty practising physicians, and give a very fair idea of the types of cases encountered and show the source of reference. In larger cities, an orthopaedic practice would vary as so frequently men confine their work more to one definite line,—such as consulting, operating, or industrial surgery.

No consideration has been given to financial matters—such as the percentage of collections—as that is too variable with general conditions, local conditions, and the individual.

AGE GROUPS

Under 1 year	17
1 to 5 years	44
6 to 15 years	48
16 to 50 years	241
51 to 70 years	45
Over 70 years	5
Total	400

SOURCE OF REFERENCE

From doctors	254
Through other patients	77
From nurses	9
Through local hospital	17
From social-service agencies	14
Sent by insurance companies	15
Referred by lawyers	3
Referred by chiropodists	5
Referred by druggist	1
Referred by osteopath	1
Called without reference	4
Total	400

MISCELLANEOUS STATISTICS

Patients who came to office once only, for consultation or examination	132
Hospital consultations	23
Hospital operations without after-care	10
Hospital operations and after-care	27
Consultations at patients' homes	4
Consultations at homes with later office treatment	3
Compensation-insurance cases	61
Cases in which court or compensation hearings were attended	4
Braces applied, other than foot supports	30
Foot cases seen and treated	77
Patients who received physiotherapy in some form	101
Non-orthopaedic conditions seen and referred to other doctors	12

DIAGNOSES

Fractures and dislocations		78
Fracture of skull	1	
Fracture of clavicle	3	
Fracture of ribs	1	
Fracture of pelvis	1	
Fracture of humerus	4	
Fracture of elbow	2	
Fracture of forearm	2	
Fracture of wrist and hand	16	
Fracture of neck of femur	4	
Fracture of shaft of femur	6	
Fracture of leg	14	
Fracture of os calcis	2	
Old fracture of spine	8	
Old dislocation of shoulder	1	
Old fracture of elbow	4	
Non-union of ulna	1	
Compound, tibia and fibula	5	
Old fracture of ankle	2	
Dislocation of astragalus	1	
Back pain including trauma		27
Shoulder pain including trauma		16
Knee-joint injuries		23
Sprained ankle		4
Contusions		5
Old hematoma		1
Coccygodynia		3
Spondylolisthesis		3
Bursitis of knee		2
Bursitis of elbow		3
Tenosynovitis of wrist		1
Loose cartilage in elbow		1
Acute pyogenic knee		1
Cellulitis of foot		1
Adherent tendo achillis		1
Osteomyelitis of femur		1
Osteomyelitis of tibia		1
Exostoses		2
Lipoma		1
Myositis ossificans		1
Snapping jaw		1
Charcot wrist		1
Congenital hypertrophy of leg		1
Fragilitas ossium		1
Paget's disease		1
Dupuytren's contracture		2
Volkmann's ischaemic paralysis		1
Musculospiral paralysis		2
Deltoid paralysis		1
Bell's facial paralysis		1
Hemiplegia in adults		3
Brachial birth paralysis		7
Spina bifida		1
Anterior poliomyelitis		12

A third slot (C) lies in the axis of the bar three-eighths of an inch from the other end. These slots perforate the bar at an angle of thirty degrees. The part which grips the foot is a strong webbed belt twenty inches long by one and one-eighth inches wide, with a T-shaped grip at one end, and a specially devised buckle at the other. The third part is a metatarsal bar three and one-half inches wide, which slides on the lever as a collar, and is capable of being fixed at any distance by means of a thumbscrew. The mechanics of the instrument are illustrated in Figure 2. The belt

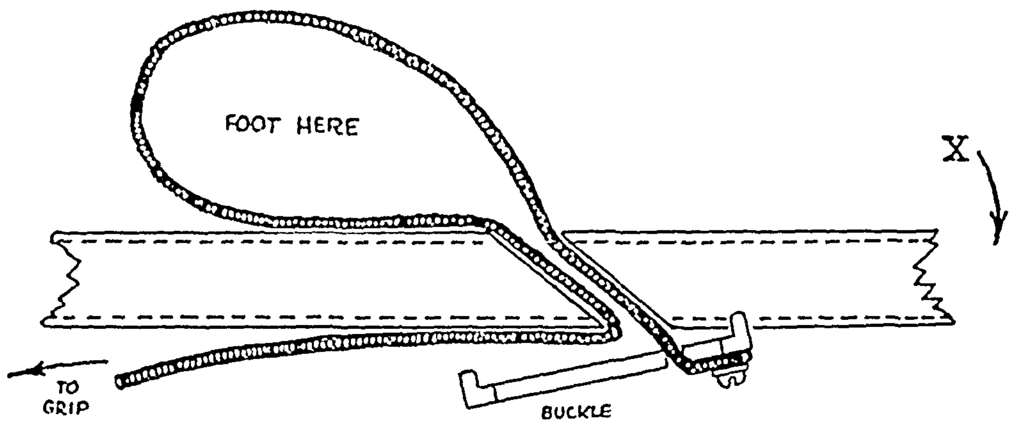

FIG. 2

is doubled on itself through a transverse slit with buckle and hand grip on the underside of the lever; the strap is then tightened around the foot by pulling on the hand grip in the axis of the lever. When pressure is exerted at X the buckle is pulled against the belt, which describes a sharp angle, so that the loop cannot slip while pressure is maintained.

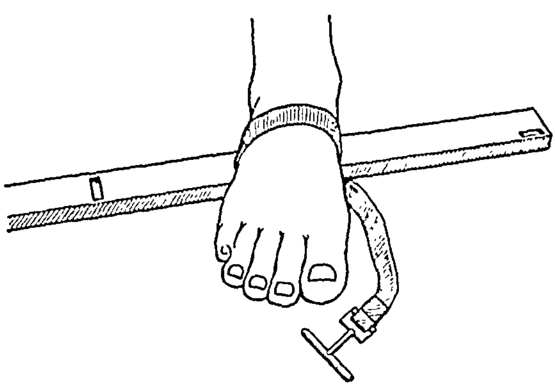

FIG. 3

The other diagrams show the application of the lever in correcting the various deformities in *talipes equinovarus*. Figure 3 shows the method of correcting the inversion. It is noted that the central aperture (B) is used, so that one hand grips each end of the bar, thus carefully controlling the amount of force applied; also that the belt goes over the point where the main deformity exists,—*viz.*, the midtarsal joint. To make the most complete use of the force applied, care must be exercised to keep the lever in the same plane as the strap. When the lever is kept parallel to the leg while adjusting the strap, the strap fits the curves of the foot most closely, and the lever automatically adapts itself to the plantar surface of the foot.

Figures 4 and 5 show the method of correcting the calcaneal inversion. Transverse slit A is used here so that the short end of the lever rests di-

rectly on the calcaneum. One hand is sufficient to manipulate the lever, leaving the other free to hold the ankle.

Figure 6 illustrates the method of correcting the equinus deformity. In this case the longitudinal slit *C* is used for the strap and the heads of the metatarsals allowed to rest on the metatarsal bar. Once the operator is conversant with the use of

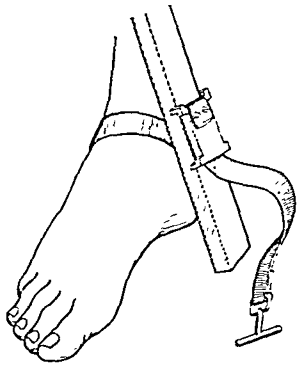

Fig. 4

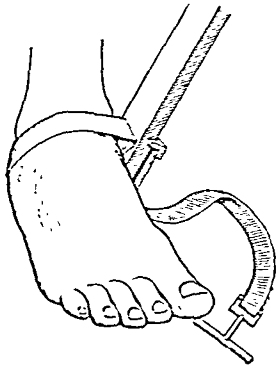

Fig. 5

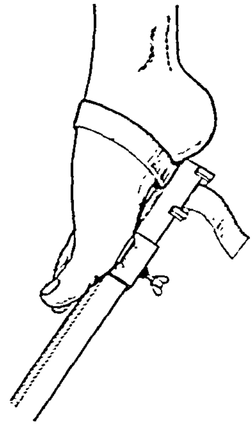

Fig. 6

the instrument he will easily see how other foot deformities, such as pes calcaneus, flat-foot, etc., can be corrected.

The instrument is as simple as a lever, and is as easily controlled. That it fits the foot and applies the force where most needed is obvious, for a *band* of force has been substituted for two *points* of force, and if a Bier's bandage is placed about the foot, not even the tender scarf skin of an infant is abraded. With such accurate apposition and control, unnecessary trauma has been eliminated.

Although the advantages of this lever are apparent, it is not suggested that it should be used as a substitute for early manual manipulation, which is preferable to any instrumental procedure, but it will be found of great value in infants as an adjuvant in gripping securely the small malformed foot. The instrument will probably be of most use in those cases of neglected and particularly recalcitrant club-foot of youth; it cannot be expected to be of much advantage where osteotomy is indicated because of the bony changes.

The writer desires to thank Prof. John Fraser of the Royal Infirmary, Edinburgh, for his interest in the apparatus. His enthusiasm was stimulating, his suggestions and the opportunities he gave for applying the lever were of incalculable assistance.

A NEW HIP REST FOR THE APPLICATION OF PLASTER-OF-PARIS SPICAS OR JACKETS IN PRONE OR SUPINE POSITIONS*

BY NATHAN H. BACHLIN, M.D., BROOKLYN, NEW YORK

While applying hip spicas, we have found that the patients almost invariably show evidence of discomfort to a greater or lesser degree; they shift positions to relieve themselves of pain, so that frequently they slide upward, resting on the upper part of the thighs, which are now necessarily flexed somewhat on the pelvis, with the pelvis and lumbar spine unsupported, slumping backward. This results in a cast improperly applied and that under difficulties.

In studying the causes thereof, we have observed that all the standard rests made—the separate rests as well as those on the fracture tables—are of a flat design and constructed near the perineal rod, so that when the patient is placed upon it, he necessarily rests on the tip of his spine, with the lumbar spine unsupported, and the weight of almost the whole body gravitating upon it.

It is an undeniable law of physics, that when a convex body is placed upon a flat surface, the entire weight will be on the crest of the convexity, no matter how large the underlying flat surface may be.

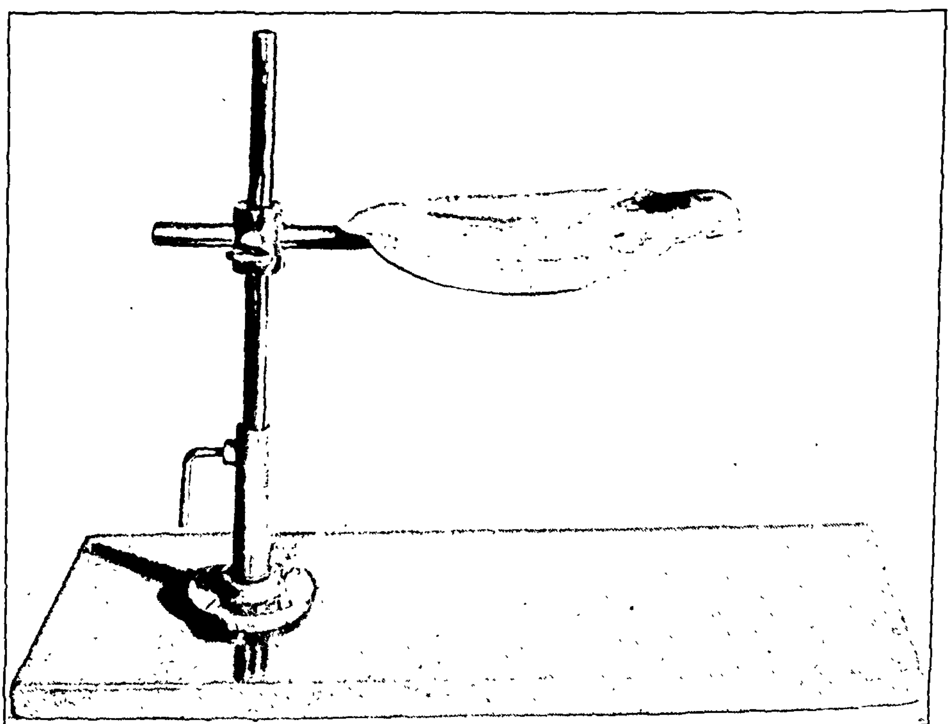

FIG. 1

Separate hip rest to be used on a table or at bedside.

* From the Orthopaedic Services of Kings County, Beth Moses, and Neurological Hospitals.

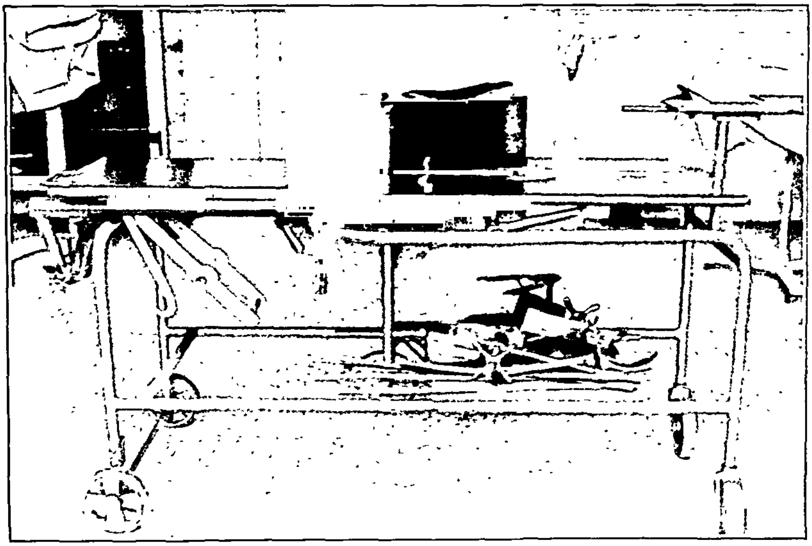

FIG. 2
Hip rest attached to fracture table.

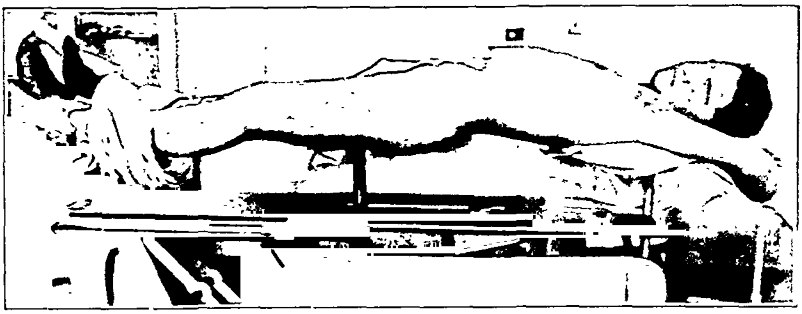

FIG. 3
Patient in position for application of cast in supine position.

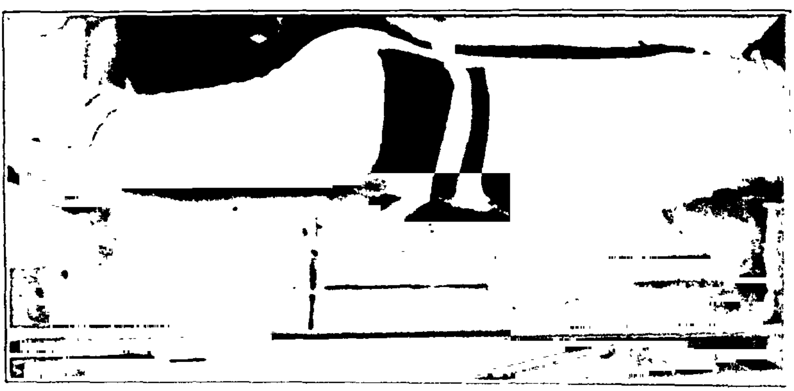

FIG. 4
Patient in position for application of cast in prone position.

In the matter under our consideration, under such circumstances, the whole weight is borne by the lower end of the spine, resting on a flat, hard, non-giving, metallic support. Moreover, since in most of these cases we are dealing with individuals who are suffering from some disease or injury that is already more or less painful, the amount of discomfort evinced by these patients is not surprising.

The normal resting parts of the lower end of the body are the gluteal regions and the tuberosities of the ischii, with the spine slightly raised between these supports, so that little or no pressure is ordinarily exerted on it.

Bearing in mind the anatomical structures of the pelvis, the support

Fig. 5

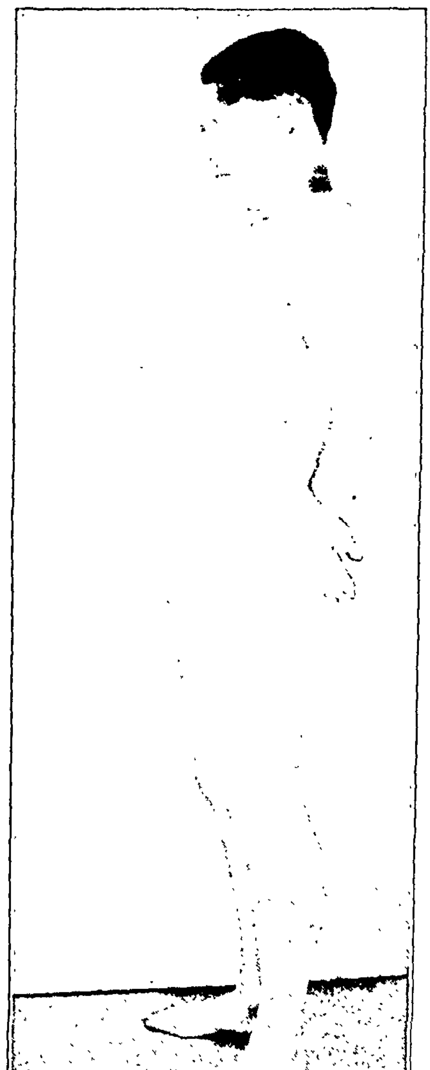

Fig. 6

Figs. 3, 4, 5, and 6 show a patient weighing about 200 pounds, suffering from pseudohypertrophic muscular dystrophy, who was fitted with a plaster corset *without any discomfort* after an unsuccessful attempt by the suspension method.

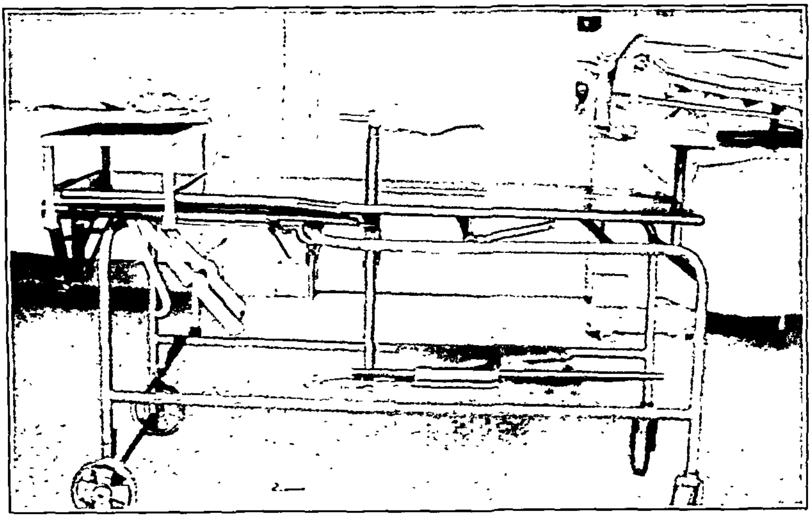

Fig. 7

Table in position for application of a jacket in a hyperextended position in fracture of the spine.

here illustrated has been devised. It conforms structurally to the shape of the sacrum, is grooved in the center for the spine so that no pressure is put upon it, and is so constructed that it can be moved upward or downward toward the perineal rod to conform to the size and shape of the in-

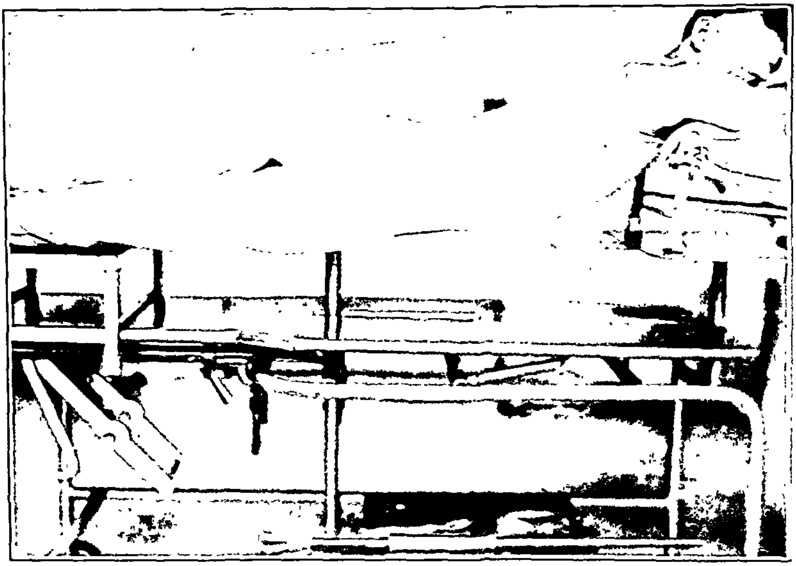

Fig. 8

Patient in position for the application of jacket in fracture of spine. Note the generalized hyperextension of spine, the degree of which can be regulated by the height of the shoulder support; also the comfort of the patient while in that position.

dividual. At its upper end there is a flange curving forward, which supports the lumbar spine in its normal physiological position: lordosis.

The patients thus placed are absolutely at rest, fully relaxed; and the lumbar spine is properly supported. The cast can now be applied with ease and without haste.

During the five years in which this apparatus has been in use, it has been found so satisfactory that the writer has discarded entirely the suspension method, finding the recumbent position more comfortable and more efficient. The support is so arranged that it will fit readily into any standard fracture table or can be used at the bedside on its own base.

In spinal corrective work, by changing the position of the upper part of the body and by exerting pressure on the required points, and with the other means at our disposal, the jacket can be applied to correct or improve the structural changes present in functional scoliosis when temporary use of the jacket or corset seems advisable. In applying the jacket in a prone position, it is possible to obtain complete correction of any existing deformity. In structural scoliosis in the same position, a greater degree of correction is obtained by molding the plaster while setting. In vertebral compression fractures or dislocations, by placing the patient in extreme hyperextension with chest elevated and the arms outstretched, and by pulling on an elevated object for further traction, one can use corrective force to reduce the dislocated vertebra or to separate the compressed body, and the patient can be immobilized without further disturbance in such a position.

THE ROLLER SKATE AS AN AID TO ACTIVE MOTION AND MUSCLE TRAINING IN CASES OF POLIOMYELITIS

BY NATHAN H. RACHLIN, M.D., BROOKLYN, NEW YORK

In cases where the muscles involved are of insufficient strength to enable them to move the limb, or in very young children who cannot be made to understand what they are expected to do, the writer has been able to get the cooperation of these patients by the use of a roller skate, and thus obtain the full benefit derived from active motion, which is of prime importance in the treatment of this malady.

Thus, to illustrate, by attaching the skate on the inner side of the leg, with the knee flexed and patient lying on opposite side, the thigh can be swung back and forth in a horizontal plane, with a minimum amount of effort, thus overcoming gravity as well as the retarding effect of the bed-clothes.

In a similar manner, by adjusting the skate to other parts of the limb in the line of the muscle pull, the same effect can be produced elsewhere, as for quadriceps and hamstring action on inner aspect of the foot, etc.

The advantages of this method are:

1. The ability to utilize a select group of muscles in a very weak state.
2. Ready and active cooperation by patients and parents.
3. Continuous and uninterrupted home treatment under supervision of nurse or parents.

News Notes

The Forty-sixth Annual Meeting of the American Orthopaedic Association was held in Toronto, June 14 to 18, under the presidency of Dr. W. E. Gallie. Mr. G. R. Girdlestone of Oxford was present as foreign guest and contributed a paper to the meeting.

The morning of the first day was occupied by clinical demonstrations of interesting cases by Dr. Gallie and his associates. The afternoon was open for the members and guests to occupy themselves at will.

On the remaining days, the following program was presented:

JUNE 16

Symposium on Arthritis:

Production of Chronic Arthritis by Injection of Weak Acids, Distilled Water, and Normal Saline.
Dr. J. Albert Key, St. Louis, Missouri.

Clinical Experimental Observations with Regard to the Injection of Certain Agents (Pregle Solution) into Chronic Arthritic Joints.
Dr. J. E. M. Thomson, Lincoln, Nebraska.

Certain Arthritic Disturbances in Parathyroid Disease.
Dr. Robert D. Funston, Detroit, Michigan.

The Physiology and Pathology of Joint Effusions.
Dr. Walter Bauer, Boston, Massachusetts (by invitation).

Orthopaedic Treatment in Spondylitis of the Strümpell-Marie Type.
Dr. Loring T. Swaim, Boston, Massachusetts.

The Influence of Diet in Cause and Treatment of Chronic Arthritis.
Dr. A. Almon Fletcher, Toronto, Canada (by invitation).

The Future of Orthopaedic Surgery with Especial Reference to Teaching.
Dr. David Silver, Pittsburgh, Pennsylvania.

Hyperparathyroidism and the Accompanying Bone Change.
Dr. Max Ballin, Detroit, Michigan (by invitation).

Arthrodesis of the Tuberculous Hip.
Dr. John C. Wilson, Los Angeles, California.
Dr. Melvin S. Henderson, Rochester, Minnesota.

Amputation Stumps of the Lower Extremity—Surgical Technique and Sites of Election.
Major N. T. Kirk, Washington, D. C.

Fracture of the Femoral Neck, Statistics and Motion Pictures—Modification of Whitman Technique.
Dr. G. W. Leadbetter, Washington, D. C.

JUNE 17

The President's Address.
Dr. W. E. Gallie, Toronto, Canada.

The Treatment of Fractures in the Light of Their Ischaemic Complications.
Mr. G. R. Girdlestone, Oxford, England (by invitation).

Alcoholization of Peripheral Motor Nerves of the Legs in Spastic Paralysis of Childhood.
Dr. Ralph R. Fitch, Rochester, New York.

Operative Arrestment of Longitudinal Growth of Bones in the Treatment of Deformities.
Dr. D. B. Phemister, Chicago, Illinois.
The Treatment of Compound Fractures, a Specific Technique for Prevention and Control of Osteomyelitis.
Dr. Fraser Gurd, Montreal, Canada (by invitation).
The Use of Bacteriophage for Osteomyelitis.
Dr. Fred H. Albee, New York City.
Crippledom and Reducing Diet.
Dr. Emil S. Geist, Minneapolis, Minnesota.
Some Biologic Effects of Light.
Prof. Brian O'Brien, Rochester, New York (by invitation).
Congenital Non-Union of the Tibia.
Dr. Wallace H. Cole, St. Paul, Minnesota.
Congenital Metatarsus Varus.
Dr. Charles W. Peabody, Detroit, Michigan.
The Relation of the Abdominal Muscles to Scoliosis.
Dr. C. L. Lowman, Los Angeles, California.
Bone Block for Paralytic Foot-Drop.
Dr. A. Bruce Gill, Philadelphia, Pennsylvania.

JUNE 18

The Nucleus Pulposus:
(*a*) Embryology, Anatomy, and Physiology.
(*b*) Clinical and Experimental Studies.
Dr. E. L. Compere, Chicago, Illinois (by invitation).
Dr. D. C. Keyes, Chicago, Illinois (by invitation).
Methods of Measuring the Internal Pressure of the Intervertebral Disc.
Dr. Charles K. Petter, Minneapolis, Minnesota (by invitation).
Correction of Compressed and Impacted Fractures of the Spine.
Dr. John Dunlop, Pasadena, California.
Dr. Carl H. Parker, Pasadena, California.
Old Dislocations at the Shoulder and Presentation of a New Instrument.
Dr. William Arthur Clark, Pasadena, California.
Fractures of the Femur in Children from a Functional Standpoint.
Dr. C. F. Eikenbary, Seattle, Washington.
Malunion and Non-Union in Fractures of Long Bones.
Dr. W. W. Plummer, Buffalo, New York.

At the last Executive Session of the Association, held Saturday following the final session, nine orthopaedic surgeons were elected to membership:

Samuel R. Cunningham, M.D., Oklahoma City, Oklahoma.
Joseph Freiburg, M.D., Cincinnati, Ohio.
Carl T. Harris, M.D., Rochester, New York.
Myron O. Henry, M.D., Minneapolis, Minnesota.
Arthur Krida, M.D., New York City.
Merrill K. Lindsay, M.D., New Haven, Connecticut.
Joseph I. Mitchell, M.D., Memphis, Tennessee.
Barclay W. Moffatt, M.D., New York City.
Rudolph S. Reich, M.D., Cleveland, Ohio.

And the following were elected Corresponding Members of the Association:

Mr. G. R. Girdlestone, Oxford, England.
Prof. A. Mouchet, Paris, France.
Prof. G. A. Wollenberg, Berlin, Germany.

The following officers were elected for the ensuing year:

President: Arthur Steindler, M.D., Iowa City, Iowa.
President-Elect: Melvin S. Henderson, M.D., Rochester, Minnesota.
Vice-President: Robert Soutter, M.D., Boston, Massachusetts.
Treasurer: John L. Porter, M.D., Evanston, Illinois.
Secretary: DeForest P. Willard, M.D., Philadelphia, Pennsylvania.
Executive Committee: W. E. Gallie, M.D., Toronto, Canada.
Membership Committee: James A. Speed, M.D., Memphis, Tennessee.
Program Committee: A. R. Shands, Jr., M.D., Durham, North Carolina.

Delegates to American College of Surgeons: Dr. William B. Owen, Dr. D. B. Phemister, and Dr. David Silver.

Delegates to the Congress of the German Orthopaedic Association: Dr. Arthur Steindler and Dr. E. G. Brackett.

The next meeting of the Association will be held in Washington, under the presidency of Dr. Arthur Steindler.

The Association received with regret the news of the death of Dr. Arthur H. Cilley.

ARTHUR H. CILLEY

Dr. Arthur H. Cilley, a member of the American Orthopaedic Association, died in New York City on May 31, 1932, at the age of sixty-two. He was also a Fellow of the American College of Surgeons and the New York Academy of Medicine. Dr. Cilley received an A.B. degree from Princeton University in 1893 and the degree of M.D. from the College of Physicians and Surgeons, Columbia University, in 1896. After completing a two-year internship at the New York Post-Graduate Hospital and one year at the Hospital for the Ruptured and Crippled, he practised orthopaedic surgery in New York City. He served with merit in the recent World War. At the time of his death he was Assistant Clinical Professor of Surgery and Associate Attending Orthopaedic Surgeon at the New York Hospital and the Cornell University Medical College Association. During the past eighteen years he has been a valuable teacher in the Orthopaedic Department and Chief of the Clinic at Cornell. He is survived by his wife and one son.

A one-day meeting of the **British Orthopaedic Association** will be held in London on Wednesday, July 27, 1932, preceding the sectional meetings of the British Medical Association.

In recognition of the twenty-fifth anniversary of the founding of the **Hospital for Joint Diseases**, New York City, a Clinical Week was held at the hospital April 15-21. A program of unusual interest was presented.

Dr. John Heberling has been appointed assistant orthopaedic surgeon to the Home for Crippled Children in Pittsburgh.

The Congress of the **Yugoslavian Orthopaedic Society** and of the **Czechoslovakian Orthopaedic Society** will be held in Zagreb, Yugoslavia, on October 3 and 4, 1932. The principal topics for discussion will be: "The Social Importance of Orthopaedic Surgery", "Tuberculosis of the Bones and Joints", "Rickets", and "Poliomyelitis". Further information about the Congress may be secured from the President, Prof. Božidar Spišič, Palmotičova 22, Zagreb, Yugoslavia.

Dr. Mayer S. DeRoy has been appointed assistant orthopaedic surgeon on the staff of the Montefiore Hospital, Pittsburgh.

The International Congress on Biliary Disease will meet at Vichy, France, September 19–22, 1932. Information about the Congress may be obtained from Dr. Frank Smithies, 920 North Michigan Avenue, Chicago.

Tumors, benign and malignant, will be the theme of the 1932 Graduate Fortnight of **The New York Academy of Medicine** which will be held October 17–28 inclusive. The medical profession of the country is invited to attend and to participate in the Graduate Fortnight. A complete program and registration blanks may be secured by addressing The New York Academy of Medicine, 2 East 103rd Street, New York City.

A most cordial invitation has been extended to the members of the American Orthopaedic Association to attend the **Twenty-Seventh Congress of the Deutsche Orthopädische Gesellschaft,** which is to be held in Mannheim on September 5, 6, and 7, under the presidency of Prof. Adolf Stoffel. The first day will be devoted to the consideration of "The Pathophysiology and Treatment of Fracture of the Neck of the Femur", and the second day to "Internal Injuries of the Knee Joint". Both of these subjects will also be considered with reference to industrial surgery. The afternoon of the second day will be given up to a discussion of "Plastic Surgery of the Acetabulum". The subject for the third day will be "Malunion of Fractures".

The next Congress of the **International Society of Orthopaedic Surgery** will be held in London, July 19–22, 1933. The following have recently been elected to membership in the Society:

Dr. Z. B. Adams, Boston, Massachusetts.
Dr. George E. Bennett, Baltimore, Maryland.
Dr. Frank D. Dickson, Kansas City, Missouri.
Dr. Emil S. Geist, Minneapolis, Minnesota.
Dr. A. Bruce Gill, Philadelphia, Pennsylvania.
Dr. Ellis W. Jones, Los Angeles, California.
Dr. Leo Mayer, New York City.
Dr. Charles Ogilvy, New York City.
Dr. H. Winnett Orr, Lincoln, Nebraska.
Dr. J. Torrance Rugh, Philadelphia, Pennsylvania.
Dr. Edwin W. Ryerson, Chicago, Illinois.
Dr. Robert Soutter, Boston, Massachusetts.
Dr. Walter G. Stern, Cleveland, Ohio.
Dr. Arthur Steindler, Iowa City, Iowa.
Dr. Philip D. Wilson, Boston, Massachusetts.

At the meeting of the **Chicago Orthopaedic Club** held on April 8 at Cook County Hospital, the program was in charge of the Orthopaedic Staff. Interesting cases were presented and papers read by Dr. Philip Lewin, Dr. Daniel Levinthal, Dr. E. J. Berkheiser, Dr. Philip Kreuscher, Dr. Marcus H. Hobart, and Dr. Arthur Conley.

At the Spring Meeting of the **British Orthopaedic Association** in Nottingham on Friday and Saturday, April 22 and 23, a large series of cases was demonstrated by Mr. Crooks and Mr. Malkin at the General Hospital and at the Harlow Wood Orthopaedic Hospital, and three clinical problems were discussed:

I. Suppurative Arthritis of the Hip

Mr. Crooks, Nottingham, presented a series of twelve cases of pyogenic infection of the hip joint. Early drainage was necessary not only to save life, but to minimize epiphyseal destruction. The classical route for drainage was by a posterior incision, but in half of the cases abscesses pointed in front of the joint and an anterior incision had been used. After operation the limb was fixed in abduction, and traction was maintained to prevent pathological dislocation. There was no mortality, and the end result in eight of the twelve cases had been a stable hip. In infants there was usually destruction of the epiphysis and of the neck of the femur, and frequently an unstable dislocation was inevitable.

Mr. Aitken, London, advised a short spica and not a calliper as an ambulatory splint. In unstable cases the ring of the calliper pushed the neck of the femur out of the acetabulum and aggravated the tendency to dislocation. He felt that operative stabilization should be performed when the patient was fourteen or fifteen years of age by constructing a new roof over the upper end of the femur.

Mr. Elmslie, London, doubted whether any attempt at operative stabilization was of value. The only measure he would advise was a bifurcation osteotomy and, although this stabilized the limb satisfactorily, it had the serious disadvantage of increasing the shortening. The best end result which could be secured was a bony ankylosis in good position.

II. Dislocation of the Patella

Mr. Malkin, Nottingham, reported seven cases of outward dislocation of the patella. In five cases the displacement was habitual and of congenital origin, and in two cases recurrent. Normally, in consequence of the erect posture of man, the oblique axis of the quadriceps maintained an angle with the vertical axis of the patellar ligament, and favored outward displacement of the patella. This was still further exaggerated if knock-knee was present. Successful treatment demanded not only replacement of the patella, but realignment of the quadriceps with the patellar ligament; in congenital cases it was necessary to dissect and free the vastus externus, and in all cases it was advisable to displace the tubercle of the tibia inward and downward. The downward displacement compensated for underdevelopment of the external condyle of the femur. If knock-knee was present, an osteotomy to correct it was essential, but the correction could be more easily secured in congenital cases by deferring osteotomy until after replacement of the patella and realignment of the quadriceps. The operation which he had learned from Mr. Elmslie, had been performed in six cases. After several years there had been no recurrence of the dislocation, and a normal range of knee movement was restored.

Mr. Elmslie said that the important features of his operation were: (*a*), dissection and replacement of the vastus externus; (*b*), displacement of the tubercle of the tibia inward and downward; (*c*), transference of a pedicle of joint capsule from the inner to the outer side; (*d*), the construction of a flap of capsule to hold the rectus femoris inward.

Mr. Fairbank, London, said that osteotomy of the femur was always necessary in habitual dislocation, but not always in recurrent dislocation of the patella. He had frequently noticed in recurrent dislocation that, although there might be no genu valgum with the knee extended, this deformity was evident when the knee was flexed.

III. Fractures of the Spine

Mr. Crooks, Nottingham, reported forty-four recent cases of fracture of the spine. The mortality was twenty-five per cent., and in almost fifty per cent. of the cases the spinal cord had been injured. Reduction of the fracture was advocated, and emphasis

was laid on the ill effect of allowing patients to lie in bed for several weeks without active treatment. In such circumstances functional complications commonly appeared, and energetic exercises in the gymnasium were necessary to combat phthisis. Twelve cases were demonstrated of crush fractures of the spine which had not been seen until several weeks after the accident, so that a slight kyphotic deformity remained. Although good movements were restored, only one of the twelve was free from pain and only two had resumed work.

Mr. Hope Carlton, London, said that the results of treatment of crush fractures of the spine had been greatly improved since the introduction of the technique described by Watson Jones, but he had found difficulty in some cases in correcting the last few degrees of wedging of the vertebrae.

Mr. Cochrane, Edinburgh, said that he had used Watson Jones' technique in reducing fractures of the spine, but in two cases paralytic ileus had arisen, and he attributed this to the hyperextension, and the lack of abdominal support during reduction. The use of a ventral hammock assisted in preventing this.

Mr. Watson Jones, Liverpool, drew attention to the constancy with which pain persisted, if the wedging of the crushed vertebrae was not corrected. Records were now available of over fifty fractures of the spine which had been reduced by his method, and, provided that the deformity was fully corrected and recurrence prevented by the wearing of a plaster jacket for a sufficiently long period, there was no pain, and fully seventy-five per cent. of the patients resumed heavy work. Consolidation of fractured vertebrae was slow, and the plaster jacket should be retained in simple crush fractures for four months and in extensively comminuted fractures for six months. Energetic exercises could be practised throughout this time and in uncomplicated cases recumbency was not necessary for more than a few days. Paralytic ileus might arise in any case where a plaster jacket was applied under anaesthesia, and was due not to the hyperextension, but to the anaesthetic and too liberal administration of morphin. No anaesthetic should be used.

Mr. Bankart, London, emphasized the necessity for immediate reduction. The pain of an unreduced crush fracture of the spine could only be relieved by operative fusion of the affected area with a bone graft. The best treatment for fractures of the lumbar transverse processes was to ignore the fracture and treat the case as a simple muscle injury, in order to avoid functional complications and to prevent adhesion formation.

Mr. Trethowan, London, said that persistent chronic backache was inevitable if crush fractures of the lumbar spine were not reduced. Since the pain was due to malalignment of the spine, he doubted whether bone grafting would always relieve it.

Mr. Naughton Dunn, Birmingham, advocated temporary splintage of the spine in order to decide whether bone grafting would be successful or not. Operative treatment could only succeed in those cases where pain was controlled by wearing a spinal support.

At an informal meeting held at the **Liverpool Medical Institution** on March 21, Dr. Jean Macnamara, who was introduced by Sir Robert Jones, gave an address on acute poliomyelitis.

The history of the treatment of infantile paralysis by human immune serum was reviewed, and the experimental basis for the therapy outlined. The succession of epidemics which had occurred in Melbourne during the years 1927 to 1931 had given an opportunity for recognition of cases before paralysis, and therefore for the treatment of cases at the stage at which serum was effective. During the first year in which serum was available, of 135 cases, only one was diagnosed before paralysis had developed; in 1931, of 270 cases, eighty-six were diagnosed and treated in the preparalytic stage.

The "dromedary type" of onset, in which the two phases of the disease were separated by an interval of apparent recovery, had been frequently observed, but more often three or four days of definite illness had preceded paralysis. The symptoms were de-

scribed as general and special. The general symptoms of fever, vomiting, constipation and headache did not differentiate from other diseases, but, in the cases which progressed to the stage of paralysis, other symptoms served as warning signals,—such as, tremor of the hands, photophobia, and retention of urine. The most important sign had been the "spine sign", a disinclination for forward flexion of the spine owing to the pain involved. In older children this sign was elicited by placing a coin on the knee and bribing the child to attempt to bend forward toward it. In infants the sign was elicited by passive flexion.

The necessity for a careful general examination, and for constant watchfulness—particularly in times of epidemics of patients suffering from an indefinite illness was stressed, in order that confirmation of the clinical diagnosis should be sought at the first appearance of warning signs and symptoms, by examination of the cerebrospinal fluid. The changes in the fluid were an increase of polymorphonuclear cells, then of lymphocytes, and later of globulin content. The estimation of the chlorid content was useful in discriminating between poliomyelitis and tuberculous meningitis.

Clinical experience in 1928 had confirmed the warning of experimental work of the danger of delay between the removal of cerebrospinal fluid and administration of serum. The procedure adopted in Victoria of examining the cerebrospinal fluid at the bedside, while the lumbar puncture needle, with obturator replaced, remained *in situ*, was described. It was important to reexamine the patient twelve to eighteen hours later, for, if the first intravenous and intrathecal injection of serum was adequate to establish a passive immunity, there should be marked improvement in the general condition and a rapid fall of temperature.

The details of the method of preparation adopted by the Commonwealth Serum Laboratories in Melbourne were given. The product fulfilled the requirements of a serum, free from hemolysis, aseptic without added antiseptic, and as free of fibrinogen as possible.

The experience in Melbourne had been parallel to that of other countries where serum had been used. The use of human immune serum in the preparalytic stage of poliomyelitis had been proved beneficial by the low mortality rate, the low average total paralysis, and the strikingly low proportion of paralysis of the severer grades. The results of treatment of 133 cases in the preparalytic stage had been as follows: in sixty-six no paralysis could be detected; in sixty paresis for some weeks could be demonstrated by careful examination, but cleared up completely with no residual paralysis; in seven treatment failed, one case proving fatal and six developing paralysis. The seven failures had taught two lessons:

A. Delay between the withdrawal of fluid and the administration of serum must be avoided (this was the probable explanation of the fatal case and of three with paralysis).

B. An adequate initial intrathecal and intravenous dose was essential, and, if the response in eighteen to twenty-four hours was unsatisfactory, a second injection of serum should be given.

Dr. Macnamara then referred to the other aspect of the treatment of acute poliomyelitis, where advice was not sought until paralysis had fully developed. In 1925, when an attempt was made to secure adequate after-treatment for every paralyzed patient, the principles which had been enunciated by Sir Robert Jones and Robert Lovett were used as the basis for the work. The patient was placed on a frame of a modified double Thomas pattern with, in addition, foot pieces, head piece, and, if necessary, arm pieces. A cloth corset had been used for abdominal paralysis. When there was involvement of the small muscles of the hand, a papier-mâché splint was applied. So long as hyperaesthesia persisted, the treatment involved complete rest on the frame, with daily immersion in hypertonic saline baths, at first for ten to twenty minutes and later for longer periods. Even during immersion, care was taken to prevent stretching of paralyzed muscles.

Reeducation was commenced when the hyperaesthesia subsided, and as far as possible this was carried out by experts. Experience in Melbourne confirmed Lovett's conclusion, that the degree of recovery which could be achieved by an expert was three times as great as that achieved by well-meaning amateurs. An accurate knowledge of the anatomy and actions of muscles was essential to prevent the development of trick movements. Furthermore, considerable experience was necessary to assess the fatigue point of the neuromuscular system which was being coaxed back to normal function. Splintage required constant supervision, and frequent modification of the position of the limb was necessary in order to give the advantage of relaxation to groups of muscles relatively weaker than their antagonists.

The principle taught by Jones and Lovett, that the greatest factor in converting a slight paresis of muscle, which is capable of recovery, into severe and permanent paralysis is fatigue, had been borne out by experience in the Physiotherapy Department of the Children's Hospital in Melbourne. For this reason when the lower limb, abdominal, or spinal muscles had been paralyzed, an endeavor was made to continue rest by splinting in recumbency with muscle reeducation, as long as any recovery was evident. The treatment was not changed until nine months had elapsed with no evidence of further recovery. Records were kept of the degree of recovery, measured periodically according to the standard of the Harvard Infantile Paralysis Commission. In many cases, more recovery was seen during the third year of recumbency than during the second year. The degree of muscle recovery was less during the winter than the summer months. If the factor of fatigue of recovering muscles was fully appreciated and prevented, it was worth while to continue recumbent treatment for longer than the two years which had usually been allowed.

CORRECTION

In the paper on Progressive Pseudohypertrophic Muscular Dystrophy by Dr. Garry DeN. Hough, Jr., published in *The Journal* for October 1931 (Vol XIII, page 825), an error was made in the dosage of adrenalin. The sentence beginning at the bottom of page 835 should read: "Their method of treatment consisted of the subcutaneous injection of two-tenths to three-tenths cubic centimeters of *a one-tenth per cent. solution of adrenalin* and one-tenth to two-tenths cubic centimeters of a one per cent. solution of pilocarpin hydrochlorid, given daily or every second day up to fifty or sixty doses without interruption."

the surprising frequency of multiple isolated and marginal lesions. The consideration of primary and secondary new growths is simple and brief. Spinal curvatures of all ages and causes are dealt with in a separate chapter. In elaboration of the original material it would be difficult to find a better summary of the literature of the subject in the brief space of two hundred pages.

A TEXT-BOOK OF X-RAY THERAPEUTICS. By Robert Knox, M.D., C.M. (Edin.). Completed and edited by Walter M. Levitt, M.B. (Irel.). New York, The Macmillan Company; London, A. & C. Black, Limited, 1932. $7.00.

This book was intended to be a new edition of a book published by Knox in 1923, but he died before it was completed. The book was completed by another radiologist with the result that it now represents the combined experiences of the two authors. It is a real *textbook* of x-ray therapeutics, treated in all its phases. The arrangement of the text is logical, the first subject considered is the effect of x-rays on tissues; then, the physics of x-ray therapy, with several chapters on measurements of x-rays, the different filters used, and the various types of machines used in therapy.

Treatment of pathological conditions is discussed by body systems. A brief statement is made as to the possibilities of treatment of lesions of the various organs,—whether results warrant it, and the technique of treatment. Very reasonable claims are made for this type of therapy and frank statements are made when the writer believes other methods of treatment offer more hope of cure.

The most detailed chapters are those dealing with the technique of therapy and it is in this field that the writers put forth certain new ideas in therapy. This section and many of the others are very well illustrated.

DIE TECHNIK DER KNOCHENBRUCHBEHANDLUNG. By Dr. Lorenz Böhler. Vienna, Wilhelm Maudrich, 1932.

The third edition of Prof. Böhler's work on fractures will be welcomed. The previous edition was reviewed in *The Journal of Bone and Joint Surgery* (XI, 885, October, 1929). This edition is enlarged, both in text and in illustration, and the author has added the results of further study of the normal and pathological anatomy, which he has applied to the methods of procedure which he has developed and has put into use in his clinic. He has also added to the chapters on the consideration of dislocations and joint inflammation and infections of the hand, which conditions are met with so frequently in his special work.

The book is a comprehensive one, including the treatment of practically all of the types of this group of injuries which come into the field of traumatic surgery. It is copiously illustrated with photographs of the types of injuries and of the various methods used in their treatment. Particularly does the book abound in the practical application and practical suggestions which are valuable not only to the surgeon who has had a large experience in the treatment of fractures and all traumatic injuries, but especially to those who are not so familiar with the treatment of these cases.

The book is a very distinct addition to the literature of this Department of Surgery.

THE TECHNIQUE OF THE NON-PADDED PLASTER CAST. By Fritz Schnek, M.D. Translated by Douglas D. Toffelmier, M.D. Vienna, Wilhelm Maudrich, 1932. $5.00.

In the large clinic of Prof. Böhler, in which a very great number of fractures are treated, retention by the plaster-bandage splint has been found to be the most effective. The immobilization of fractures after reduction—especially of the fractures with infected wounds—is essential and the most effective method is always sought for. The unpadded cast has been found preferable in their hands. The author discusses the essential features of both the padded and the unpadded methods of the use of plaster and meets very

clearly the objections usually raised to the unpadded plaster-of-Paris cast by the description of the technique for its application and also by the results obtained by it. He shows also the objections to the padded cast and the unfortunate results often following its use. He clearly demonstrates the advantages of his method, and, as in all surgical procedures, familiarity with the technique and professional skill are essential. Realizing this, the author has given detailed and accurate explanations for the use of this method, including the making of the plaster-of-Paris bandage itself, and the making of the plaster-of-Paris splint, with its application to the part. He also discusses the points necessary for the care of the plaster and the observation of the patient, the method of removal, and its preparation for its reapplication as a removable splint. He emphasizes the care necessary in the position of the limb, not only in the application of the plaster, but also in the position of the patient in the after-treatment. With the same thoroughness of detail, the author considers the application of the general principles of technique to the various fractures in the different parts of the body, the position of the limb, and the special application of the splint to the various fractures.

The book is profusely illustrated. Of special value are the illustrations of casts which are incorrectly applied and the demonstration of faults to be particularly avoided. This work will be found most suggestive and helpful to anyone who wishes instruction in the skilful use of plaster as a means of immobilization.

Rheumatic Infection in Childhood. By Leonard Findlay, M.D., D.Sc., M.R.C.P. New York, William Wood & Company, 1932.

The etiological significance of acute articular infections to all types of arthritis has been so frequently questioned that there is found in this study of 701 cases of acute articular rheumatism by Findlay an extremely suggestive commentary. The material at his disposal has been very carefully worked up and the author's wide experience has enabled him to handle it in a very conclusive fashion. The modern view appears to be that it is a chronic disease with a decided tendency to acute exacerbation. The very great frequency with which it plays a rôle in the causation of heart lesions, its relations to chorea, and its tendency to manifest a selective affinity for certain fibrous (rheumatic nodules) serous tissues of the body are well brought out. The historical development of its lesions from Baillou's first description in the sixteenth century down to and through the time that auscultation (1816) came into use, as well as the later developments, are interestingly cited. Morbidity and mortality statistics, and the relation of sex, age, and environment to incidence, are based upon recent and comprehensive surveys made abroad and in this country. Failure to positively identify a constant, causative bacteriological factor by the numerous observers who have made such claims does not, in the author's view, prove that it is not a disease of bacteriological origin, but leads him to incline to the parasitic theory, principally for the reason that its response to specific treatment puts it in the class with syphilis and known spirochaetal diseases manifesting such behavior to certain specific drugs. It may be that there is a non-filterable organism that is responsible. Scarlet fever, tuberculous polyarthritis, and syphilis may give rise to some confusion in diagnosis. The arthritic manifestations of rheumatism are its most characteristic phenomena. The joint effusions, whether they be serous or purulent, have an abundance of cellular elements, polymorphonuclear in character, but on examination by cultural or staining methods do not contain organisms. Onset is usually rapid, distribution multiple, but there is a tendency to skip from joint to joint and less acid perspiration is noted than in the adult. Of the 701 cases forming the basis of this study, 322 had arthritic lesions, and of this number 72 per cent. showed cardiac damage. One hundred and eighty children had chorea as well as arthritis, and of this number seventy-one per cent. had cardiac lesions. Endocarditis, myocarditis, pericarditis, chorea, skin rashes, and rheumatic nodules occur in varying frequency in the articular rheumatism of childhood. He discusses the relation of tonsillar inflammation to the incidence of the disease and in his personal experience found it present in only four per cent. of his own

the clinical material and to include excerpts from the more valuable recent contributions to the medical literature. The first volume comprises a three-hundred-page analysis of the general problems of health insurance and industrial medicine, and five hundred pages of detailed case summaries and clinical discussions of accidental injuries. The topographical arrangement facilitates reference to specific regions as the detailed index adds to ease of finding the discussions of the typical and rare traumatic lesions. Characteristic of the entire presentation of material is the correlation of the problems of the local clinician with those of expert examiner and insurance adjuster. Official decisions which have established precedent are given in abstract with references to the original sources. As a guide to the estimation of disability, the handbook should be valuable to the industrial surgeon and to all who are involved in care of accident cases.

PAPERS ON SURGERY AND OTHER SUBJECTS. By George Tully Vaughan, M.D., LL.D., F.A.C.S. Washington, D. C., W. F. Roberts Company, 1932.

The taste which must be catered to in the book-reading public is varied and this is true in respect to medical publications as well as to general literature. Formal compilations of the facts of importance in diagnosis and treatment are essential, in the shape of textbooks. Scientific monographs, adding to the sum of knowledge within a narrow field, are of the greatest importance. Historical and biographical contributions, bringing out the trends of thought and the lives of those who have played significant rôles in advancing the profession, are becoming more widely sought, and, finally, the setting forth of the experiences of those whose clinical opportunities for study have been extensive often contains material that is interesting and valuable. To this latter class belongs this volume of Dr. Vaughan's. The subjects treated cover a wide range of general surgery varying in importance from transplantation of a knee joint to circumcision. Interspersed are numerous papers on general subjects,—from the Execution of Edith Cavell, given as an address before a graduating class in a nurses' training school, and Bullfights in Vera Cruz to Companionate Marriage. The contents of the book is the passing in review of the materials out of which has been evolved a successful career. Such an account has its interest and its value.

DAS MÜNCHENER SONDERTURNEN UND ANDERE WEGE ZUR KÖRPERLICHEN ERTÜCHTIGUNG. Edited by Geh. Hofrat Prof. Fritz Lange. Munich, J. F. Lehmann.

In this small volume, written by himself and several of his confrères, Dr. Fritz Lange has presented most practical information for the gymnastic teacher and the physiotherapist, as well as the practising physician, on those physical conditions and defects which can be treated by physical exercise and the simpler hygienic measures. Many of the postural and stature defects are described and their development explained. Considerable space is devoted to the subject of nourishment and hygienic measures. The correction and treatment by exercises is given in detail and illustrated by many photographs. The book is devoted to a field not usually covered, and is presented in a way which makes it available to those who should find it of use in their daily work.

The Journal wishes to acknowledge the receipt of the following publications sent to the Editorial Department:

Annaes Paulistas de Medicine e Cirurgia. S. Paulo, Brazil, Vol. XXIII, Nos. 1, 2, 3, and 4, January, February, March, and April 1932.

Norsk Magasin for Laegevidenskapen. Oslo, Vol. XCIII, Nos. 4, 5, and 6, April, May, and June 1932.

Kirurgiske Pankreassykdommer og Postoperative Pankreaskomplikasjoner. Kliniske Studier. By Olav Usland. Tilleggshefte til Norsk Magasin for Laegevidenskapen. Oslo, Vol. XCIII, No. 4, April 1932.

Høifjells-Sanatoriet i Gausdal. Prospektus for 1932 samt Laegeberetning for Sesongen 1931. Bilag til Norsk Magasin for Laegevidenskapen, Vol. XCIII, No. 4, April 1932.

Anales del Instituto de Biologia. Mexico, Vol. II, No. 2, 1931.

Ortopedia e Traumatologia dell' Apparato Motore. Rome, Vol. IV, Fasc. 2 and 3, April and May 1932.

Journal de Médecine de Bordeaux et du Sud-Ouest. Bordeaux, Vol. CIX, No. 7, March 10, 1932.

Bulletin of the National Tuberculosis Association. Vol. XVIII, Nos. 5 and 6, May and June 1932.

The Johns Hopkins University Circular. School of Hygiene and Public Health. Catalogue and Announcements for 1932–33. Baltimore, No. 436, April 1932.

A Second Study of the Prevalence of Syphilis and Gonorrhea in Upstate New York. By Albert Pfeiffer, M.D. and Herbert W. Cummings. Albany, New York State Department of Health, 1932.

The Responsibilities and Opportunities of the Social Worker in the Field of Social Hygiene. By Herbert W. Cummings. Albany, Division of Social Hygiene, New York State Department of Health, 1932.

DOPPELSEITIGER MB. KIENBOECK BEI 2 BRÜDERN (Bilateral Kienböck's Disease in Two Brothers). Axel Ringsted. *Acta Chir. Scandinavica*, LXIX, 185, 1932.

The fact that changes of the os lunatum characteristic of Kienböck's disease may be demonstrated by x-ray in the absence of definite clinical findings and symptoms is substantiated by one of the cases reported. With two bilateral out of a series of fourteen cases, there is a definite suggestion of symmetry of the lesion. While the etiology is obscure, trauma is unlikely as a primary cause and constitutional factors are of some importance. The two cases are reported in detail.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

AN OSTEOGENIC SARCOMA OF A DOG: PATHOLOGIC AND ROENTGENOLOGIC OBSERVATIONS. W. H. Feldman and F. A. Ford, *Am. J. Cancer*, XVI, 377, 1932.

The authors describe a tumor of the left ulna of an English setter, and present roentgenograms and histological studies on the basis of which the tumor was diagnosed as an osteogenic sarcoma. The tumor established pulmonary metastasis and progressed to a fatal termination in spite of amputation and x-ray treatment in massive dosage. Reports of similar tumors occurring in other animals are briefly reviewed.—*G. W. Taylor, M.D., Boston, Massachusetts.*

UNDIFFERENTIATED ROUND-CELL SARCOMA OF THE ILIUM (EWING TUMOR) CONTAINING HEMOPOIETIC ELEMENTS. N. W. Roome and P. A. Delaney. *Am. J. Cancer*, XVI, 386, 1932.

The authors report a case of a large primary tumor of the ilium in a young man, with widespread skeletal metastases. The article is well illustrated with roentgenograms and photomicrographs. Special staining methods demonstrated the presence of differentiated cells of the hemopoietic series as well as undifferentiated hemocytoblasts. On the basis of these findings they class the tumor as a Ewing sarcoma, possibly merging into a hemocytoblastoma.—*G. W. Taylor, M.D., Boston, Massachusetts.*

NOUVELLE TECHNIQUE DE L'ARTHRORISE TIBIO-TARSIENNE ANTÉRIEURE PAR LAMBEAU ASTRAGALIEN PÉDICULÉ. (New Technique for Anterior Bone Block of the Ankle by Pedicle Graft from the Astragalus.) L. Michel. *Rev. d'Orthop.*, XIX, 51, 1932.

The author finds that the original operation of Putti, in which the tibial graft is inserted into the astragalus at the anterior margin of the ankle joint in order to block dorsiflexion, is unsatisfactory because the graft breaks. In Putti's recent operation a

pedicle graft from the neck of the astragalus is turned up from below upward and bone chips are packed in behind it. Apparently this is a satisfactory operation, but the author reverses the direction of the pedicle, that is, with the foot held in a position of equinus, the anterior portion of the astragalus is exposed and, beginning at the articular surface, a pedicle graft is elevated with its base downward. Then the foot is immobilized in a position of slight equinus. The operation should always be accompanied by subastragaloid and occasionally by midtarsal arthrodesis. —*J. Albert Key, M.D., St. Louis, Missouri.*

Arthrodesis of Hip, With Special Reference to Method of Securing Ankyloses in Massive Destruction of Joint. L. C. Abbott and F. J. Fischer. *Surg. Gynec. Obstet.*, LII, 863, 1931.

The authors describe a method of hip arthrodesis designed for hip joints with extensive destruction due to pyogenic or tuberculous infections. Correction of the deformity is the first stage and is brought about by simple adhesive traction, or, if necessary, by skeletal traction following an operation designed to free the trochanter from the ilium.

After the extremity has been brought into wide abduction, so that the greater trochanter approximates the acetabulum, the patient is ready for the second stage,—the arthrodesing operation. Through a Smith-Petersen incision, cortical bone is bared in the upper and inner aspects of the acetabulum and on the superior, anterior, lateral, and posterior aspects of the upper end of the femur. Broad contact of cancellous bone to cancellous bone is brought about by widely abducting the leg, and placing the upper end of the femur into the acetabular bed. At this time the main point is to gain accurate contact by as much abduction as is necessary, and the line of weight-bearing is ignored. A double spica cast secures the fixation.

The third stage consists of a subtrochanteric osteotomy, followed after several weeks by gradual bending of the callus until that position of the hip is secured which permits the best possible function of the extremity. The callus is usually perceptible by means of the x-ray two weeks after the osteotomy, and bending of the callus by traction usually consumes about ten days. The desired position is maintained by traction and is carefully and repeatedly checked. It is believed that this careful checking and gradual correction brings about a more perfect functional position than can be gained by operative correction and plaster fixation in one stage.

Eleven cases are reported; disease was quiescent in nine. In one of these cases, ankylosis had not taken place in one year. Sinuses were present in two of the cases,—in one, ankylosis and healing had taken place in fourteen months; while, in the other, ankylosis and healing was not present eleven months after operation. The results were highly satisfactory in all but the two cases.—*Hugh Jones, M.D., Los Angeles, California.*

Fractures of the Metatarsal Bones During Marches. H. Turner. *Voyenno-Med. J.*, II, 188, 1931.

The author presents a detailed review of functional disorders of the foot. A great number of authorities are cited on the subject of the so called march fractures of the foot. This affliction usually appears in young soldiers after a prolonged march; it is manifested by pain and swelling of the dorsum of the foot. The x-ray study shows a slow-growing thickening of the periosteum of the metatarsals, osteoporotic changes, and subsequent solution of continuity simulating fractures. The author had an opportunity to remove fragments of such a metatarsal for study. He came to the conclusion that the affliction is a neurotrophic disease of the bones of the foot produced by functional injury to the terminal branches of the deep peroneal nerve, causing secondary pathological changes in the metatarsals with possible late linear fractures.—*Emanuel Kaplan, M.D., New York City.*

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THE ANGLE OF GAIT: A STUDY BASED UPON EXAMINATION OF THE FEET OF CENTRAL AFRICAN NATIVES

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"What is the correct position for the feet?" Physicians, physical directors, gymnasium instructors, and others interested in bodily welfare are repeatedly being asked this question. In earlier days only military authorities and dancing masters gave any apparent thought to this matter; they prescribed a position with the heels together and the toes separated to an angle of ninety degrees. That position is still maintained in the regulations of many continental armies, but chiefly for ceremonial purposes, such as "standing at attention", or "passing in review".

Bradford in 1897 was among the first to report actual observations on the subject and to record disapproval of a wide angle for the feet which he recognized as a distinctly artificial posture. His exposition of the common range in positions of the feet, from one of in-toeing to wide out-toeing (often associated with weakness of the feet), apparently received wide attention among other orthopaedic surgeons.

Although Bradford's interpretation of the normal posture gave it a moderate range of out-toeing, the parallel position of the feet, even with some amount of adduction, was seized upon as specific evidence of foot strength. Prompted, no doubt, by the desire to counteract the obvious weaknesses of wide out-toeing in flat feet, the profession first endorsed the parallel position of the feet as a therapeutic measure; soon, however, it became commonly accepted as the ideal foot posture.

The completeness with which opinion had swung in this direction is clearly reflected in a statement by Hoffman, quoted from his report on an examination of the feet of natives brought to the Louisiana Purchase Exhibition for the Philippine and Central African exhibits. His statement reads, "I must say that I was somewhat disappointed at not finding the straight or leverage gait as common among primitive peoples as I had

FIG. 1
Preparation of an examination area.

supposed; though, on the whole, it is far more common than among shoe-wearers".

The conservative conclusions of Bradford and Hoffman, who had given the subject careful study, seem to be overreached by many of the present advocates of the straight-toed position, who so emphatically affirm the correctness of this posture, alleging it to be characteristic of the Indians. Foundation for their assertions, however, is notably absent. Except for two works undertaken at Stanford University, under the able direction of Prof. A. W. Meyer, there is little in the way of formal examinations with statistical reports upon which definite conclusions regarding the correct position of the feet can be determined. One of the examinations, dealing with 229 male college and high-school students, was reported by Dougan; and the other, of 150 female college students, was reported by Patek.

While acknowledging the unique value of these later contributions, it is obviously desirable to check the results against conditions which prevail among people living in primitive surroundings; for it is only under such circumstances that we can be sure of interpreting natural gait without danger of the conclusions being perverted through the use of conventional footwear or by well-intentioned advice on the manner of walking.

An opportunity to examine such a group was recently realized in the expedition* sent to Africa in 1929 under the auspices of Columbia University and the American Museum of Natural History (New York). The

*The members of the expedition were Prof. E. T. Engle, Prof. W. K. Gregory, Prof. J. H. MacGregor, and Mr. H. C. Raven (leader). All of them are Staff members of one or both of the Institutions named.

Fig. 2
Making foot records at another site.

importance of such an examination was considered sufficient to justify its inclusion as one of the special objects of the Expedition.

Appreciation of the labors expended by the members of the Expedition in procuring the desired footprints is sincerely acknowledged. The work was not performed among the conveniences and facilities of a well equipped gymnasium, but had to be carried out under real difficulties. There was no smooth floor upon which to lay the kinetographic board on which the footprints were made. Whenever a suitable group of natives was gathered, a favorable area had to be selected in the open and, with native help, graded to a level surface. Usually this was done, and the subsequent examination performed, under the trying conditions of equatorial winds and rain, or beneath a blazing sun whose scorching rays made relaxation in a shady spot far more appealing to the members of the party than the effort to collect material for problems in which they had more of a friendly, than personal, interest.

Nor were the natives any too cooperative in the labor of preparing the necessary space. The digging, grading, and stamping down of loose earth involved work toward which they showed more reluctance than curiosity, and even less enthusiasm. At least, such was their attitude until Prof. Gregory conceived the happy idea of attaching a bit of pagan ceremony to the undertaking. This change was accomplished by means of a couple of resonant tin containers and with the help of Prof. MacGregor and Prof. Engle. With a few rhythmic drumming strokes and

lusty "yah! yahs!" as an overture, a very responsive chord was touched, with the result that quickly the long narrow space became crowded with enthusiastic dancers who now stamped down the earth with rapturous abandon (Fig. 1).

When the desired area had been prepared, the kinetographic board (about eighteen feet long and eighteen inches wide) was laid upon it. This was covered in order by a wide strip of inked fabric, similar in texture to typewriting ribbon, a corresponding stretch of paper, and a narrow sheet of muslin. Each native was directed to walk from one end of the board to the other so that an average of from six to eight footprints of each individual was thus recorded (Fig. 2). Fine longitudinal corrugations on the upper surface of the board were registered in the footprints on each sheet of paper, so that the angle of the feet to the line of body movement could be easily measured.

Impressions were gathered of 147 natives belonging to three tribal groups of the Belgian Congo,—the Ounyabonga, Wafaleru, and Wambuti (pigmies). The distribution as to sex and age within these groups was as follows:

TRIBE	MALE	FEMALE	CHILDREN	TOTAL
Ounyabonga	58	1	5	64
Wafaleru	21	26	20	67
Wambuti	8	3	5	16
	—	—	—	—
	87	30	30	147

The total number examined has proven sufficient to determine the dominant habits in foot posture, as well as to give the comparative frequency and range of departure from the position in which the feet are most commonly used. Its subdivisions, however, are admittedly too small to yield reliable information on sex and age differences.

As remarked by Dougan, in his report, the results of such an examination emphasize two other phenomena, besides the angle of gait, that invite particular interest. One of them is the notable *Asymmetry* in the angle of the right foot and of the left foot in many individuals; the other is the *Variability* in the angle of each foot as demonstrated in the succession of footprints obtained in each test.

ANGLE OF GAIT

The term "Angle of Gait" has been applied to the habitual position or angle assumed by each foot to the line of motion as a person walks. Of course, if the normal or correct position is one in which the feet are parallel to that line, as inferred by the so called "Indian-walk", then any angle must be viewed as a departure from the normal. Consequently the fundamental nature of the question, introduced by that supposition, as to what is the normal position, justifies us in turning immediately to the ultimate result of the examinations.

Measurements of the total number of footprints (over 1000) gave an average angle of approximately seven and five-tenths degrees. Figure 3 shows the distribution of all footprints (both rights and lefts) within adjacent arcs of five degrees. The largest number of feet (twenty-nine per cent.) showed an angle of between five and ten degrees; the next largest group (twenty-five per cent.) lay between zero and five degrees; the third largest number (eighteen per cent.) had an angle between ten and fifteen degrees. On one side of that fifteen-degree arc, thirteen per cent. of the total number of feet showed an angle of from fifteen to twenty-five degrees of out-toeing. On the opposite side, a slightly greater proportion (fifteen per cent.) showed in-toeing, as represented in the three five-degree arcs between zero and minus fifteen degrees.

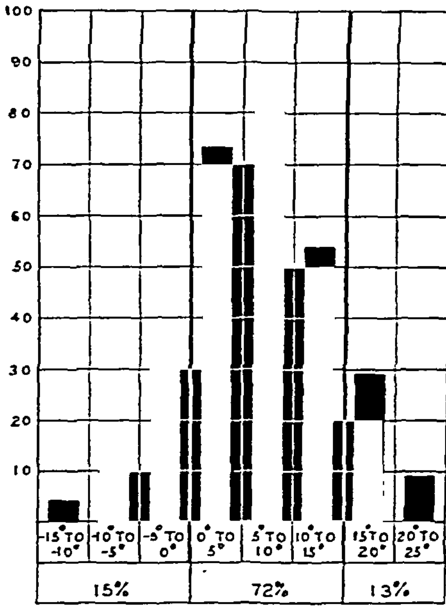

Fig. 3

Distribution of the angle of gait in all native feet (rights and lefts).

A second calculation was made on all feet included in the larger middle groups, comprising seventy-two per cent., to determine what their average angle might be. It gave a result of seven and six-tenths degrees, a mere shade wider than the seven and five-tenths degrees obtained as the average measurement of the total number of footprints.

VARIABILITY OF THE ANGLE

The positions which a foot assumes in a single series of steps are by no means constant in relation to the line of body movement. Thus, of the 147 natives examined, there were but three instances in which the angle varied less than four degrees in the three or four imprints taken of each foot. Variation in the angle of gait sometimes showed as great a difference as fifteen to twenty degrees in the impressions taken of a single foot. The average range of difference, however, was eight degrees, with the left foot showing a slightly greater amount, eight and three-tenths degrees, to seven and seven-tenths degrees for the right foot.

In previous studies by the author, it has been found that three or four tests on a single individual reduced this average range of variation from an arc of about eight degrees to one of five. Hence, if an allowance of two and five-tenths degrees be added on each side of an established average angle, the resulting arc will give a truer representation of how the examined foot is ordinarily used. For this reason, and in order to

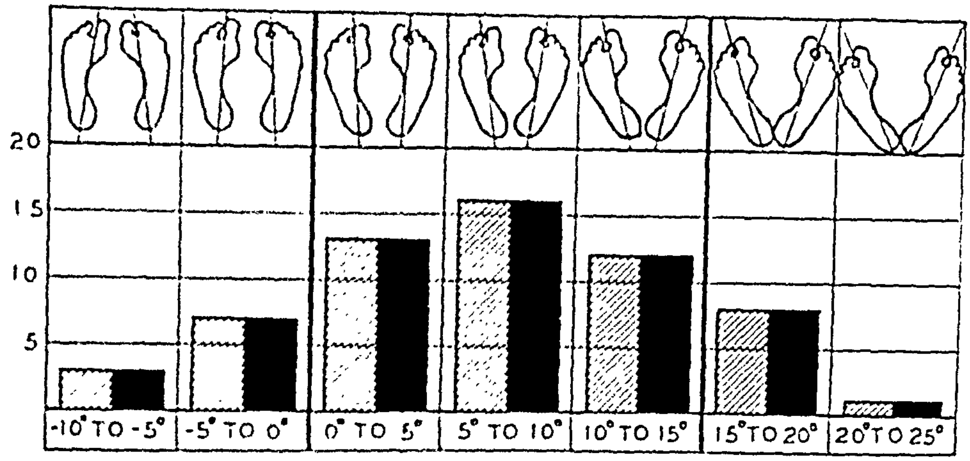

FIG. 4
Distribution of symmetrical cases showing the average angle in each group.

avoid cumbersome tables of statistics, it has seemed more satisfactory to group the feet within arcs of five degrees instead of using the actual measurements obtained from the examination.

SYMMETRY AND ASYMMETRY

Symmetry. Dougan stated that only six of the 229 students examined by him averaged the same angle of gait in their right and left feet. Patek found *none* in her 150 cases, and only five instances in which a difference of less than one degree was noted. Owing to the marked inconstancy in the angle of gait referred to in the previous paragraph under the term "variability", a coincidence of exact figures for each foot, averaged from a single test, seems too severe a criterion to employ in judging the presence or lack of symmetry in gait. If an arc of five degrees be recognized as an *allowable* range of normal variation, as suggested in the preceding paragraph, a truer and more practical estimate of symmetry is afforded. On such a basis, a grouping of the results of the African examinations within arcs of five degrees permits sixty of the 147 natives (forty-one per cent.) to be considered as having a symmetrical angle of gait. Their distribution, according to the width of the angle, is shown in Figure 4 and Table I.

TABLE I

DISTRIBUTION OF SYMMETRICAL ANGLE OF GAIT

Angle of Gait	*Total*	*Ounyabonga*			*Wambuti*			*Wafaleru*			*Totals Sex and Age*		
		M	F	C	M	F	C	M	F	C	M	F	C
−10° to − 5°	3	2							1		2	1	
− 5° to 0°	7	1			1		1	1	2	1	3	2	2
0° to + 5°	13	6		1		1	1	1	1	2	7	2	4
+ 5° to +10°	16	9	1	2	1	1		2		1	12	1	3
+10° to +15°	12	5						4	1	2	9	1	2
+15° to +20°	8	1						3	2	2	4	2	2
+20° to +25°	1									1			1
Total.................	60	24	1	3	2	2	2	11	7	9	37	9	14

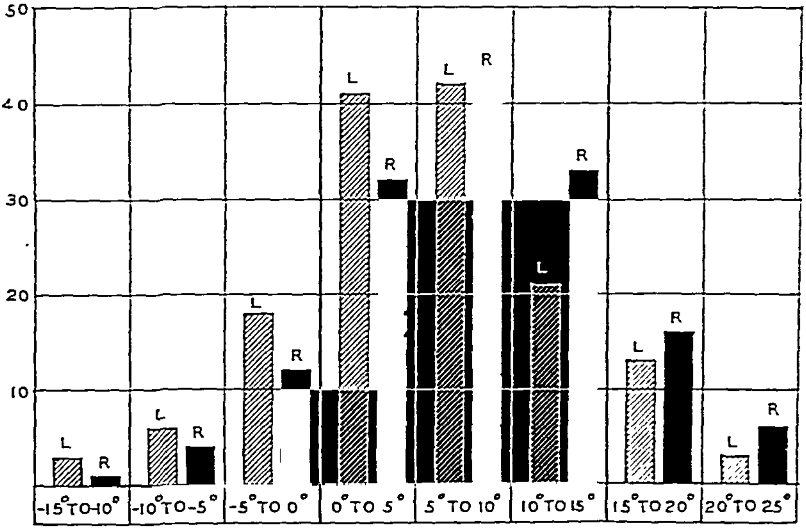

FIG. 5

Comparison of angles in left and right feet, showing dominance of smaller angles in the left and of greater angles in the right.

Asymmetry. When the angles of all right and all left feet are computed separately (Fig. 5), the results give a distinctly greater average angle, eight and three-tenths degrees, to the right foot, as compared to six and seven-tenths degrees for the left foot. The distribution is shown in the accompanying table (Table II). Although these figures are one degree higher than the averages obtained by Dougan (seven and two-tenths and five and eight-tenths degrees), the difference between the two sides is practically the same, and the right side has shown the greater angle in

TABLE II

TOTAL AVERAGES IN ANGLE OF GAIT IN RIGHT AND LEFT FEET

Sex and Age	*Ounyabonga (64)*			*Wambuti (16)*			*Wafz'eru (67)*			*Total (147)*		
	No	Average Angle		No	Average Angle		No	Average Angle		No	Average Angle	
		R	L		R	L		R	L		R	L
Men	58	8.0°	8.0°	8	8.5°	6.0°	21	9.0°	8.6°	87	8.3°	7.[illegible]
Women	1	10.0°	10.0°	3	7.3°	5.0°	26	7.9°	4.6°	30	7.9°	4.8°
Children	5	8.0°	6.2°	5	3.4°	−4.0°	20	10.2°	7.1°	30	8.9°	5.1°
Total	64	8.0°	7.8°	16	7.1°	2.6°	67	8.9°	6.7°	147	8.3°	6.7°

both examinations. Patek, however, obtained somewhat different results in her examination of female college students; her figures gave very similar averages of deflection of the feet, but with a half degree greater angle on the left side.

But the phenomenon of asymmetry does not receive its proper valua- ion in averages obtained from the total number of measurements. In- lusion of the sixty symmetrical records obscures the amount of postural lifference characteristic of the really asymmetrical cases. If the latter be onsidered alone, the amount of asymmetry in right and left feet becomes nanifest in appreciable proportions. Hence, for the eighty-seven natives vith unequal angles of gait, the average amount of asymmetry measured pproximately eight degrees for each side. Sixty-three had the greater livergence on the right side, while only twenty-four had it on the left. The greatest amount of asymmetry in a single individual, as based on his verage figures, was nineteen degrees.

IN-TOEING AND OUT-TOEING

In-toeing. Bilateral in-toeing occurred in ten individuals,—five men, hree women, and two children; in three of the adults, two men and one voman, the angle was minus ten degrees.

In-toeing on one side only was present in twenty-four instances. In ccordance with the foregoing observations on asymmetry, in which the maller angle falls more frequently on the left side, in-toeing was present n eighteen left feet and in only six right feet. The extreme examples for he right and left sides were minus twelve and minus fifteen degrees espectively.

Dougan recorded one case of bilateral in-toeing, while unilateral in- oeing was present in four cases for the right foot, and twelve cases for the eft. His extremes were minus six degrees for the right foot and minus ight degrees for the left.

Patek, with no instances of bilateral in-toeing, listed six unilateral ases on the right side and two on the left. A negative angle of five egrees was the maximum for each side in her results.

Out-toeing. As previously stated, seventy-two per cent. of all the ative feet examined were included in the arc between zero and fifteen egrees. This arc, through such strength in numbers, might be regarded s representing an acceptably normal range for the average angle of gait, vith fifteen degrees as the outside limit. Outside of that range, nine frican natives showed bilateral out-toeing,—four men, two women, and hree children. In every case except one, the average angle of the two feet ell within an arc between fifteen and twenty degrees. The single excep- on was a child whose feet showed a twenty-five degree angle on each side, nd, according to notations which accompanied the footprints, this child vas one of the few individuals seen during the Expedition, who had a efinite static derangement of the feet.

There were twenty cases of unilateral out-toeing; thirteen examples ccurred in the right foot and seven in the left. Twelve of these twenty ndividuals were adult males. The greatest average amount of out-toeing n these asymmetrical cases was twenty-five degrees for the right side, and or the left side, twenty-four degrees.

In Dougan's examina-
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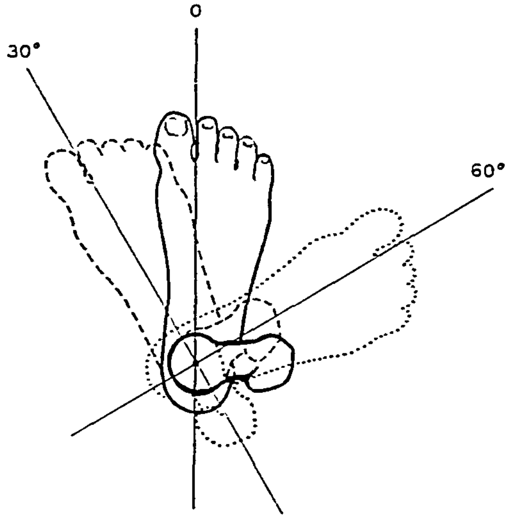

Fig. 6

Correlation of lateral movements of the feet with the 90-degree arc of hip rotation.

DISCUSSION

The position of the foot the line of body move- it, as implied in the term ngle of Gait", is not a fixed phenomenon like the single plane of rement between adjacent segments of a hinge joint,—as, for exam- flexion and extension of the foot on the leg, or of the leg on the thigh. hough a certain amount of lateral movement of the foot is permitted the subastragalar articulation and by the knee, the design of these its is such that, under the assumption of body weight, all segments of lower extremity (foot, lower leg, and thigh) gravitate into a fairly stant relationship with each other; and the angle of the foot in walking running is determined essentially by the position of the femur in its ety-degree arc of rotation at the distant hip joint (Fig. 6). Conse- ntly, the angle of gait is not so much an entity in itself as an index to functional position of the femur within its quadrant of rotation.

The longitudinal axis of the foot projected upon this quadrant ncides with the juncture of its inner and middle thirds. In-toeing is, refore, synonymous with internal rotation of the femur, having a ximum range of about thirty degrees; and out-toeing, with external ation and its possible range of sixty degrees. Consequently, when a nt so freely movable as the hip serves as the axis for the lateral positions the foot, variability in the angle of gait is hardly a matter for surprise. fact, the ninety-degree range of smooth and unobstructed lateral tion allowed in the hip speaks for the remarkable coordination in the ion of the hip rotators, whereby the angle of gait is maintained as con- ntly as it is within a very limited segment of that quadrant.

The functional position of the femur, as indicated by the angle of t, takes into account with every step the combined requirements of omotion and of the preservation of body balance. The hip joint is

extremely sensitive to changes in the lateral balance of the body. That sensitiveness is manifested in the different positions a foot occupies in each series of successive strides, and underlies the phenomenon referred to as "variability" in the angle of gait. Locomotion in its detailed workings is a subconscious act. We may voluntarily control the direction and the speed of our movements; but the performance of the act in all its intricate details, involving the strength and the sequence of individual muscle actions for movement and for protecting the vertical balance of our bodies, is under control of a wonderfully developed inner mechanism which operates quite independently of our conscious thought.

Continuous variation in the position of the feet may seem a very unnecessary and even an undesirable feature as we seek to identify some ideal walking angle; but, when we realize that it represents specific responses of the rotating muscles of the hips which are constantly adapting the position of the feet in protection of the balance of our bodies, the phenomenon demands far greater respect. We are then able to appreciate the fact that *variation* in the angle of gait is as normal as the angle of gait itself.

There are three distinct phases of foot function,—standing, walking, and running; each of them imposes somewhat different functional requirements. When a person stands, the feet must be placed so as to preserve body equilibrium in all directions. Their length takes care of forward and backward balance, while lateral balance may be secured by either an out-toeing position or by separation of the feet.

Running and walking, as phases of locomotion, are quite different phenomena from that of standing; they are dependent upon an actual loss of body balance in a forward direction. In running, the weight center of the body is allowed to fall well forward into a position where the leg and foot can give it a strong forward push from behind; subsequently, each leg in turn catches the body weight and gives it another push as the body advances. In running and sprinting, athletes point their toes straight forward; their feet are brought close to the mid-line in order to exert their propelling effort as directly behind the center of weight as possible, and their parallel position affords the maximum leverage action. During such movement, the element of lateral balance is reduced to a minimum because of forward momentum of the body mass, and because the weight center is so far off balance in that direction; hence, if a runner is tripped, he falls forward and face-downward. Similar lack of need for lateral support is observable in the vertical position of a rapidly rolled hoop.

With running and standing as opposite functional extremes in the phenomenon of lateral balance, different speeds in walking represent the intermediate phases. Just as the hoop tends to fall on its side as its speed lessens, so our need for lateral support increases with a slowing of gait, and decreases with faster movement. Such direct relationship between the rate of body movement and lateral stability is naturally manifested in corresponding changes in the position of the feet whereby necessary stability is furnished.

As previously stated, lateral support may be procured either by tu ning the toes outward or by separating the feet. Which of these two methods fits most effectively into the mechanics of walking?

In Figure 7, AA and $A'A'$ represent the lines of movement followed by the center of body weight. The two types of stride are illustrated: the first, with seven and five-tenths degrees of out-toeing; the second, with the feet separated and parallel. Both strides are given equal lateral stability by the heads of the fifth metatarsal bones E and E' being p aced the same distance from the mid-line. The difference in the two strides lies, therefore, in the distance of the points F and F', representing the center of the ankle, from the mid-line; from these points the propelling thrust is exerted against the weight center as the body moves forward. It may be noted that in the first case, with the heel close to the mid-line, the thrust from F against the weight center W throws the latter forward but *within the outer margin of lateral support* (of the opposite foot) almost immediately after it passes the toes. At a similar point, W' in the parallel stride, the thrust from F' is directed definitely *outside the margin of lateral support* furnished by the foot in front.

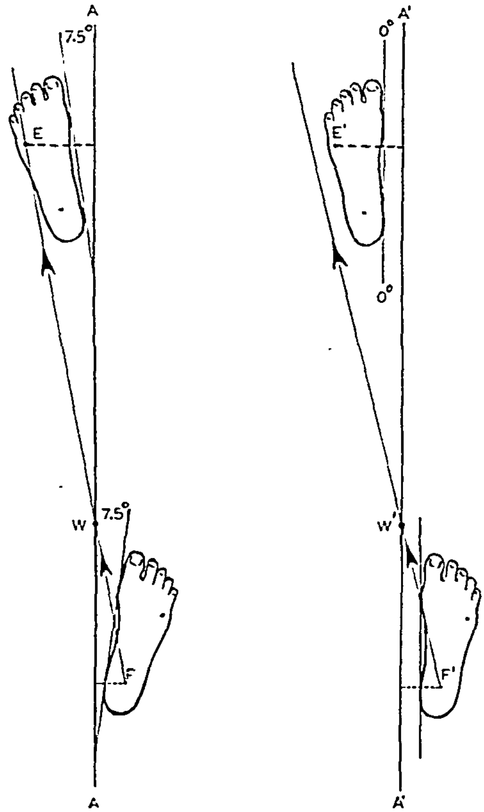

FIG. 7

Comparison of the mechanics of a stride in 7.5 degrees of out-toeing and with the feet parallel. (See text.)

The foregoing analysis recognizes two functional elements in the mechanics of a stride: (1) lateral stability, effected by widening the position of the feet as a base, and (2) a forward thrust from behind the moving center of body weight. In regard to the latter, the closer the heels are used to the mid-line, the more directly forward is the thrust exerted against body weight, so that a correspondingly lesser amount of disturbance is imposed upon lateral balance. Whereas, with a separation of the heels, increased obliquity is given to the forward thrust, which tends to rock the body from side to side with each step. A moderate amount of out-toeing meets most effectively the requirements of lateral balance in walking, while its approximation of the heels insures a smooth and direct forward movement. In contrast, a parallel position, with the feet close to

the mid-line, sacrifices a degree of security in lateral support, or, if the feet are separated, obliquity of the forward thrust tends to disorder the lateral balance and to introduce a swaying of the body in its forward movement.

This interpretation designates a moderate degree of out-toeing as the ideal position of the feet in walking; at the same time it recognizes that the angle is constantly subject to change according to the rate of movement. Moreover, it seems to explain the uniform predominance of such an angle in all three of the examinations that have been undertaken. If the African tests may be accepted as revealing most truly the natural gait, then seven and five-tenths degrees can be regarded as the angle of choice; and, with two and five-tenths degrees of allowable variation, the arc between five and ten degrees would represent the ideal range. This estimate would give an angle of between ten and twenty degrees between the two feet in ordinary active walking. A more rapid pace would tend to close that angle, and a more leisurely stride, to widen it.

As for the position of the feet in standing, an angle of forty-five degrees between the feet, as suggested by Bradford, seems the most reasonable and natural. For at this angle the spread of the feet across the balls for lateral stability is greater than the length of the feet for anteroposterior balance.

Factors have been identified which tend to influence a widening in the usual angle of gait,—such as age, stoutness, exhaustion, uneven surfaces, anatomical variations, and pathological disorders, although there is no absolute relation between these factors and the angle of the feet. As examples, aged and heavy individuals are to be seen who walk "pigeon-toed" instead of toeing outwardly as the rule would presuppose; also flat-foot cases may toe out widely or they may toe in. The chief value of these observations, however, is to emphasize the fact that the angle of the foot is not a fixed affair, but that it has a possible range of variation corresponding to the arc of rotation of the hip joint, which is the real axis for the angles assumed by the foot.

The range of difference in the positions of the feet of African natives was distinctly greater than the range observed in both examinations of American students. This does not seem strange, however, when we consider the difference in their respective environments. Smooth floors and pavements of civilized communities minimize changes in the position of the feet and would tend to establish a more constant and habitual angle; in contrast, the uneven ground surfaces of a primitive environment and less formality in the native mode of life would encourage much greater freedom in the movements of the hip and feet that could very naturally have been registered in the angles of their footprints.

Asymmetry in the angle of gait was first observed by Bradford, and also discussed by Dougan and Patek. In their examinations, as well as in the present one, it has been sufficiently prevalent and of such degree as to designate it a common and definite actuality. Dougan suggested as its

cause greater dependence upon the right leg for bodily equilibrium, or better muscular development on that side through its greater use in other purposes. Patek was apparently not impressed with these explanations, as she found the average angle greater on the left side. In certain physical activities—such as ball-throwing, spear-casting, etc.—which are more common to males than to females, the right foot is used at a much greater angle by right-handed persons than the left; such activities, engaged in from early childhood, might have shown some bearing on the sex differences if right-handedness and left-handedness had been correlated with the foot examinations. But too much promise cannot be given to this possible explanation, for in the African examination greater deflection of the right foot was about equally spread among the men, women, and children.

Right-leggedness and left-leggedness may be connected with this asymmetry, but, under most favorable conditions, dependable data on this point are difficult to obtain and the attempt was out of the question in the native tests. It seems reasonable to believe that the condition may result from the combined effect of multiple minor asymmetries in structure of the two sides, or in some cases may be no more than persistent habit as a sequela of previous injury. At any rate, when more than half of the natives showed an average of eight degrees of asymmetry with the greater angle either in the right or in the left foot, its source must involve a multiplicity of factors which are now obscure.

CONCLUSIONS

Three formal examinations of the feet of presumably normal individuals (two, of American male and female college students; the third, of African natives) are in agreement in demonstrating that the predominating position of the feet in walking is one of moderate out-toeing.

The tests contradict the idea commonly held that a parallel position of the feet—the so called "Indian method"—is the correct and natural posture.

It is true that there was a somewhat greater proportion of natives who showed a straight, or in-toeing, position than obtained among college students; but, on the other hand, the proportion of out-toeing in excess of fifteen degrees was also greater among the African natives. Both of these postural groups represented merely small minorities on either side of the large middle group, comprising seventy-two per cent. of all the feet examined.

The average angle of gait among African natives was seven and five-tenths degrees. Although this figure is slightly greater than that obtained from American college men and women, the average differences resulting from each examination are too small to have any particular significance.

Inconstancy in the angle of gait, as shown in any series of successive steps, has been strikingly emphasized in all three of the examinations; so

much so that an arc between five and ten degrees of out-toeing seems to give a more faithful estimate of how a foot is normally used than an arbitrary angle of gait arrived at by mathematical averages. It was within that arc (between five and ten degrees) that the angle of gait in the greatest number of native feet was located.

Physiological analysis of walking concurs with the foot examination in designating seven and five-tenths degrees in out-toeing (an angle of fifteen degrees as formed by the two feet) as the ideal angle of gait in ordinary active walking. Rapid movement tends to narrow that angle, slower movement to widen it.

An angle of forty-five degrees between the two feet seems to be the most natural position in standing.

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THE TREATMENT OF FRACTURES IN THE LIGHT OF THEIR ISCHAEMIC COMPLICATIONS*

BY G. R. GIRDLESTONE, F.R.C.S., OXFORD, ENGLAND

May I begin by saying how deeply I feel the honor and the responsibility of addressing the American Orthopaedic Association. Part of the responsibility, however, rests upon your President, Dr. Gallie, who was kind enough to invite me to do so. This subject has been chosen because the relationship between the activities of a bone and the circulation in it is fundamental, and because we can hardly remind ourselves too often that a consideration of the possible defects of the circulation within a broken bone and in its environment should be allowed to exercise a profound influence on our treatment of fractures.

There is an old saying, "Hard words break no bones", nor when bones are broken do soft words mend them! For they require something more dynamic than a good bedside manner. Yet there is danger inherent in the mechanical efficiency of our modern methods; danger lest the craftsman forget that union cannot be imposed but may have to be encouraged! For a bone is a plant with its roots in the soft tissues and, when its vascular connections are damaged, it often requires not the technique of a cabinet-maker but the patient care of a gardener.

Today I propose to discuss three forms which the ischaemia may take, and to indicate how vital is the right choice of treatment. There is one form which we shall call "traumatic arterial ischaemia" because it originates from damage to the arterial supply of one or both fragments at the time of the fracture. Though this form of ischaemia is much commoner than Volkmann's, comparatively little attention has been paid to it; and this is particularly unfortunate because whenever it occurs, and is unrecognized, the delay in union which follows appears inexplicable, and the line of treatment which seems right is likely to prove wrong! Later will come the story of a very remarkable case which drove this home to me by a series of bitter blows.

First, then, let me briefly review the secondary and, in the main, avoidable ischaemias.

A. SECONDARY ISCHAEMIA

Here the ischaemia is not the direct result of the injury, but arises subsequently. There are two forms:

1. *Volkmann's Ischaemic Contracture, the Result of Sudden Localized Pressure*

This tragedy needs no detailed description here. As a result of the ischaemia the highly specialized and delicate muscle cells die and are re-

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placed by fibrous tissue. All the uncertainties which made it so formidable have, in recent years, been cleared away, and, now that we understand its causation, we can (almost always) prevent its development. The essential factor is blockage of the venous return by rapidly increasing pressure, but in the elbow this is often complicated by damage to the brachial artery and median nerve. The pressure may arise within, or be applied from without; common factors are tight bandaging, splint pressure, flexion in the presence of swelling, or imperfect reduction, and a subfascial hematoma.

The latter is of special importance as a subfascial hematoma can produce ischaemic contracture without external compression, *without flexion above ninety degrees, and even without a fracture.* There are unmistakable warnings which must be looked for and relieved without delay. And this is a matter of great urgency, for a case has been recorded in which a surgeon reduced the fracture at the beginning of his list of operations, but when he saw the patient again in the ward at the end of his list, four hours later, permanent damage had been done. This was before the mechanism was understood, and I believe that watchfulness and immediate relief of venous back pressure, as soon as it is manifest, will insure the survival of the delicate neuromuscular tissues.

The following is an illustrative case:

A girl of seven fell from a pony and sustained a supracondylar fracture of the humerus. When seen five hours later, the whole region of the elbow was tensely swollen. The veins of the hand were distended. The ischaemia was venous, for, with the elbow at 120 degrees, the radial pulse could be detected, but it was very small and was promptly obliterated by flexion above ninety degrees.

It was felt that the tense swelling of the part would make reduction dangerous to attempt, and, if achieved, impossible to control. It appeared wise first to relieve the compression, then, a few days later, to reduce the fracture when the vascular state of the arm was safe and the elbow could be flexed enough to maintain reduction. An anaesthetic was given and three openings were made through the deep fascia. Though no great amount of extravasated blood escaped, the pressure was relieved (and that has been my experience in the three cases I have dealt with). The fracture was gently manipulated into better position, but, as there was still much general swelling, the arm was left supported well below a right angle.

Roentgenograms taken a few days later showed that there was still some displacement. Operative reduction was then recommended as a more delicate, accurate, and therefore safer method than manipulation. Another opinion was sought, the same advice given, and open reduction carried out with a good result.

In such cases, and whenever reduction has been previously and unsuccessfully attempted under anaesthesia, open reduction rather than further manipulation is advocated. In view of the danger to vessels and nerves, it is preferable to approach the fracture from the antero-internal aspect and to begin by identifying the brachial artery and median nerve, tracing them down to their perilous position on the jutting edge of the upper fragment. Once they are freed and protected, reduction is easy and safe.

2. An Ischaemia Due to Relatively Prolonged and Widespread Constriction and Disuse

This is followed by a condition which has been called traumatic osteoporosis; but I regard that title as misleading in that the changes, at least in the cases which it has been my privilege to see, are by no means confined to the bones. This condition is included today because I believe it to be a sympathetic dysfunction secondary to an ischaemia, provoked by compression, and prolonged by disuse, during which all the normal afferent sympathetic stimuli are abolished. It affects most commonly the forearm and hand of patients past middle life. The distal parts are swollen and cool; the skin is smooth and of a dusky red color. There is pain and great impairment of active and passive movements. Roentgenograms show a characteristic, widespread, and extreme decalcification with osteoporosis. Köhler speaks of this type of bone atrophy as indicating an acute inflammatory change. But surely it is not inflammatory! It appears rather to be a severe disturbance of sympathetic function.

Three conditions usually combine to produce this distressing condition,—middle life, firm bandaging, and immobility of the hand, either imposed or assumed.

Diagnosis

In its established state this is obvious. But safety lies in the avoidance of its causes, and a second chance is given by recognition of its early signs and symptoms. These are illustrated in the following case:

An elderly lady was brought to me with a comminuted Colles' fracture only one hour old. Under local anaesthesia the fracture was reduced and the accuracy of reduction confirmed by roentgenograms. The wrist was put up in plaster, including the forearm and the carpus, but leaving the hand free. She was given a sling and the most strict and explicit instructions to let her doctor (or me) know immediately if she had pain, or any swelling, blueness, pallor, or coldness of the hand. This was in the morning and she was comfortable all day, but, after she went to bed, the part became painful. Unfortunately, "she didn't want to worry" either of us! The pain kept her awake and in the morning she sent an urgent message to her doctor, which somehow in transit lost all its urgency. So the doctor did not call until late in the morning and it was nearly one o'clock before I saw her. By that time the circulation of the lower forearm had been constricted for fourteen hours. The hand was cool and rather dusky, with some dulling of sensation and impairment of intrinsic action. From the subsequent appearance it was clear that the swelling inside the plaster had been due to extensive extravasation of blood. Fortunately, she did well, but for some weeks had a good deal of pain and a mild degree of the sympathetic dysfunction which has been described.

This case has convinced me that it is unsafe, except when the patient is under skilled nursing supervision, to apply any unyielding splintage to a limb within a few hours of a fracture. The surgeon cannot foretell the amount of swelling which will later take place; nor is it easy for the patient to know how much discomfort she should expect and at what point she should send for help.

B. TRAUMATIC ARTERIAL ISCHAEMIA OF ONE OR BOTH FRAGMENTS

There is one well recognized form of which I can quickly dispose,—*viz.*, an intra-articular fracture in which there is complete or almost complete devascularization of the small fragment. Common examples are most fractures of the carpal scaphoid and some of the femoral neck; probably the so called osteochondritis dissecans should be included, but that is a by-way we must avoid today. The devascularization of these fragments is made evident in subsequent roentgenograms in that they do not share in the surrounding decalcification. And the treatment of such fractures is to hold the fractured surfaces in contact, accurately and uninterruptedly immobilized, until the free fragment has been revascularized by the growth of vessels from its better half—however long it takes! The progress and ultimate completion of this change is shown by the advancing equalization of the density of the two fragments. But in the hip, as Phemister has pointed out, revascularization is not enough; further patience and protection are required, for weight-bearing is only safe after the young bone has become retrabeculated. In the carpal scaphoid, even if bony union does not occur, painless function generally follows, provided that due patience has been exercised, and that means six months or more of continuous immobilization of the wrist in full dorsiflexion with natural use of the hand.

I am, however, mainly concerned with ischaemia in fractures of the shafts of the long bones. The admirable experiments of Johnson[1] have demonstrated the share taken by the nutrient, periosteal, and metaphyseal vessels in maintaining the blood supply of the shaft. Though in bone the establishment of anastomotic circulation is always relatively slow, yet Johnson's experiments showed that, after the nutrient artery had been avulsed or severely damaged, the endosteal circulation was reestablished in a few weeks, and that in the meantime the whole bone remained alive. But our clinical experiences are less happy, probably because a healthy young dog compares favorably with an underexercised, overclothed, and otherwise pampered man. Phemister[2] indeed speaks of aseptic necrosis as occurring in shaft fractures, but as a temporary almost transitory state, and being dealt with rapidly by "creeping substitution". I believe this to be a common cause of delayed union and of non-union. And I prefer to call the condition "ischaemia" as a term which includes all degrees of defective circulation. For their ordinary day-to-day duties the cells in a bone are provided with an adequate supply of blood. Any diminution tends to subdue their activities, and, in accordance with the degree of ischaemia, the cells pass from quiescence to suspended animation or even death. The union of a fracture is between three parts,—fragment, callus, fragment. So long as either fragment remains short of blood, union is delayed. For the exceptionally heavy task of union, the cells require a plentiful blood supply for function and circulation balance.

Now delayed union due to ischaemia may bring one up against great difficulties: prolonged immobilization without function is a negative

policy, like wrapping one's talent in a napkin and burying it when interest is most needed; on the other hand, function may present difficulties of splintage and the patient may grow restive. Because of these obstacles, the attractions of operative interference may become almost irresistible. Operations, however, in the presence of ischaemia are futile and worse than futile. May I quote an illustration in sack-cloth and ashes?

In July 1928 a very healthy and athletic young man of twenty-two years of age and weighing 200 pounds, while riding a motorcycle, was struck with great force in the mid-thigh by the mudguard of a lorry. Seven weeks later, despite the maintenance of good apposition on a Thomas splint, there was no sign of union nor of callus. I operated and found the ends in apposition, but each was capped with gray, avascular fibrous tissue without any organized link between them. The fracture was grafted, by Albee's method, from the tibia and a plate, made of bone, was applied. The limb was kept on a Thomas splint, but some weeks later both graft and plate broke across at the site of fracture and at the end of seventeen weeks there was no sign of union nor of callus. The patient was gotten up in a walking caliper with a plaster bucket to control the fragments as accurately as possible.

Twenty-five weeks after the fracture, there was still no sign of union, though some periosteal callus had just begun to appear on the upper fragment some two inches *above* the site of fracture. The victim was getting restless and I thought that a very strong graft would offer a prospect of union. I was careful to avoid any unnecessary exposure of bone in order to preserve its vascular connections. I found perfect bone-to-bone contact without intervening fibrosis or synovialization, but *no callus*. I fixed a massive graft, seven inches long, firmly into place and put the limb back on a Thomas splint with ice-tong extension.

Ten weeks later, the graft broke across at the site of the fracture and all sign of the callus, even at a distance, had disappeared. For reasons which at the time appeared sound, I operated again, finding the ends still in perfect apposition, but white and avascular. I applied a very massive graft and two plates made of bone, one on the inner and one on the outer side.

Six weeks later, there was no sign of callus; so again I got the patient up in a walking caliper. The victim and I were now resigned to patience!

Eight months later—*i. e.*, one year and seven months after the fracture—some callus was appearing, but only on the inner side and behind. At this point I put in osteoperiosteal grafts on the outer and anterior aspects, and in twenty-two months after the fracture the femur had at last united.

Then came restoration of movement to a very stiff knee, and this was an extremely tough job, involving extensive tenotomy of fibrosed, extracapsular structures. But now all is well.

In March 1931 he was playing hockey and wrote the other day, "The leg I am glad to say is marvelous. . . . I hardly notice the difference in the two."

The traumatic arterial ischaemia in this case was extreme and extraordinarily persistent, but I feel responsible for its prolongation. Once the bone ends had been exposed at my first operation and the bloodless state of both fragments thereby discovered, I had the essential information and rightly got the patient up in a walking appliance, but he should have been kept in it much longer. Had it been possible to prevent outward angulation of the femur, I should unquestionably have done so. The patient, however, was very heavy and muscular, and, though the end-to-end apposition remained perfect from the first operation onward.

whenever powerful extension was removed the femur angulated outward, snapping strong grafts and bone plates like twigs. Viewed in retrospect, he should have been kept in a walking caliper, angulation or no, until the appearance of callus in connection with both ends proved that the ischaemia was over. The operations in the middle period were useless and must have deferred the establishment of a normal sympathetic reflex syndrome. That the patient and I reached a good result together was due to his loyalty! But he had been subjected to a series of difficult and serious operations, of which at least two might have been avoided!

Such a case as this makes one think hard and painfully and the experiments of Johnson[1] give one a standard. I am driven to the conclusion that in order to explain such persistent avascularity of part of the shaft of a long bone we must deduce a dysfunction of the local sympathetic system. Therefore, the following etiological description of traumatic arterial ischaemia is suggested:

A. Origin, damage to the arterial supply of one or both fragments.

B. Secondary factors capable of aggravating or prolonging the schaemia.

1. Circumferential compression.
2. Powerful traction applied rapidly, tending to strangulate the bruised and infiltrated tissues in the neighborhood of the fracture, through which tissues the reestablishment of the circulation around the ends of the fragments is normally brought about.
3. Total disuse of the limb, with abolition of all the natural vasodilatory, afferent impulses which are associated with function.
4. Further traumata such as premature and repeated operations.

Diagnosis

One may suspect arterial ischaemia from the site of the fracture or the absence of any interfragmental hematoma. And if some weeks later, despite good apposition of the fragments, there is no union and no sign of callus, a tentative diagnosis of ischaemia can be made.

TREATMENT

1. Patience. The gardener does not dig up his plants to see how their roots are doing! Even manual examination may damage the delicate young vascular connections, and premature operations are not only worthless, but tire the patient and add further trauma. I suggest that the persistence of ischaemia in cases such as have been described implies a dysfunction of the local sympathetic system and that operations aggravate this dysfunction, in addition to deferring the corrective influence of natural function.

2. Continuous, accurate immobilization without constriction. This should interfere as little as possible with the movement and function of

the neighboring parts. Lateral mobility must be avoided for it stimulates the fibroblasts in the neighborhood, and the fibroblasts in these cases have a dangerous majority over the osteocytes on account of the absence of any contribution of cells from the fragments; or if one speaks, in the fashion of the moment, of the region as populated by histiocytes, lateral movement tends to make them behave like fibroblasts rather than osteoblasts, producing fibrous tissue rather than bone.

3. The third remedy is function—of the whole limb and of the bone itself.

a. Activity, sensory and motor, of as much of the limb as possible, directed toward the initiation of afferent, sympathetic impulses, and thus toward active hyperaemia through the local and ganglionic reflex arcs. This active hyperaemia is a physiolcgical response to stimuli of a physiological order.

b. Function of the bone itself,—*e. g.*, either in an active form (weight-bearing), or in a passive form, in which vibration is applied by a hammer (H. O. Thomas), or by a vibro-massage machine. For vibration is the natural stimulus which makes bone cells work.

In addition, there is much clinical and experimental proof of the value of periodic, mild, venous congestion,[3] though continuous venous congestion appears to delay or check osteogenesis.[4]

The moral of my story is that, in dealing with any and every fracture, we should remember the vital importance of the circulation. In reduction any disentanglement should be carried out with the vascular anatomy in mind, and when axial extension is advisable the pull should be increased gradually to avoid strangulation. After reduction we have to solve this problem: How to maintain accurately the position of the fragments without any constriction of the circulation, but with the splintage so well fitted that there is a minimum of interference with the function of the limb. It is an old saying in the trade that we must make the limb fit the splint, in the sense that the splint must be the master. But we can only do so rightly and safely if we begin by making the splint fit the limb as we wish it to be. Then the hold need not be extensive, the hand can be freely used, the foot given movement or weight-bearing. Function should be reasonably easy and not uncomfortable. The uninjured parts of the limb can hardly be used too soon, but the injured parts need a period of repose. From all the tissues used comfortably and naturally will arise afferent impulses promoting hyperaemia, and there will be transmitted to the bone stimuli of the order which will activate rather than overload the osteoblasts. For we know that, *ceteris paribus*, function and blood supply balance, that there is a local control of circulation, partly through ganglionic, and partly through forked nerve-axon, reflexes; and we know that bone cells can build or unbuild, changes of environment provoking a characteristic response from cells whose hereditary and life-long craft has been the care of bone. It is for us to see that the cells are stimulated to-

ward osteogenetic activity, and that the activity is maintained by circulation which is generous in quantity and in quality.

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SUMMARY OF DISCUSSION

Dr. D. B. Phemister, Chicago, Illinois, has not been impressed with devascularization as the cause of non-union in simple fractures, though experimentally it has been recognized microscopically. Operations on ununited fractures, previously treated, have shown necrosis related to the non-union, and a case is cited in which a section of the femur one and one-half inches long was found in such a condition at operation. In the femoral head, and elsewhere, aseptic necrosis does occur and is an important factor in delayed or non-union. In the x-ray increased density of the necrotic femoral head should receive recognition.

Dr. Fred H. Albee, New York, is a believer in the importance of devascularization in non-union and has always advocated care at operation to avoid interference with blood supply and measures to increase it where possible. With these objects in view, he advises the inlay graft, long enough to contact with well vascularized tissues, fitted with a cabinet-maker's nicety, and secured by kangaroo tendon. Immobilization is required for at least eight weeks; weight-bearing should be allowed only after union has been proven by physical and x-ray examination.

Dr. W. E. Gallie, Toronto, agrees that fractures at the elbow should not be put up in acute flexion until swelling has ceased. In the matter of aseptic necrosis he is in agreement with Mr. Girdlestone and Dr. Phemister, though he feels that the presence of such necrosis is no bar to the introduction of a bone graft.

Mr. Girdlestone, closing the discussion, thinks it logical to expect aseptic necrosis in the human since it has been demonstrated experimentally in dogs. He thinks persistence of necrosis in one and one-half inches of bone, in Dr. Phemister's case, five months after operation, could be explained only on sympathetic dysfunction. He believes we must discriminate between sclerosing and non-sclerosing bone in which there is dysfunction of the vasomotor system.

THE RELATION OF THE ABDOMINAL MUSCLES TO PARALYTIC SCOLIOSIS *

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The loss of the integrity of the abdominal musculature is fraught with serious consequences to the harmonious function of the body as a whole, and is far more serious than has been appreciated heretofore, if one can judge by the meagerness of consideration given it in the literature, the paucity of comment by teachers, and the lack of surgical consideration of its structural aspects by general and orthopaedic surgeons.

Lange, of Munich, in his article on American and German Orthopaedic Surgery, in *The Journal of Bone and Joint Surgery* for July, 1931, (*XIII*, 479), makes the following observation:

"When scoliosis is present, due to a paralysis of the erector trunci muscles, in America correction by the Hibbs fusion operation is often attempted. In Germany we use only supporting braces and exercises. An operative method for overcoming paralysis of the abdominal muscles (though much to be desired) has, so far as I know, not been attempted."

It is my purpose to call attention to efforts we had made to meet such a situation, and demonstrate that plastic repair of the abdominal wall, other than what is used for hernial defects, is possible and a larger field of usefulness is open to exploration and development.

It is unnecessary to more than mention the very extensive literature on the subject of fascial transplants. The experimental work of Gallie, Le Mesurier, and their coworkers, of McNealy, Andrews, Pitzman, Haas, Koontz, as well as the surgical work of many other exponents of the practical use of fascia in repair of structural defects, is well known.

A thorough search made in the libraries of the American College of Surgeons and of the American Medical Association resulted in finding many references to the repair of abdominal wall defects, but none specifically relating to the subject here presented.

In 1924 we had occasion to treat a very sturdy young country girl for acute poliomyelitis, which involved chiefly her shoulder-girdle region, with the upper abdominal wall group, recti, and obliques. We recorded the possibility of scoliosis developing in the dorsal region, and knew that it would, in consequence of the location, be very difficult to combat.

This girl was kept in recumbency for months, and not allowed up, even afterward, without a carefully fitted back brace. Despite definitely graded, pool and other muscle-reeducation treatments she continued to develop scoliosis. Other factors of health were negligible; cooperation by parents was 100 per cent; no time was ever lost nor treatments interrupted, but curvature began before the erect position was allowed. Constant study and observation led us to conclude that the interference with proper

* Presented at the Annual Meeting of the American Orthopaedic Association, Toronto, June 17, 1932.

abdominal muscle function was in some way contributory to the scoliotic condition. It was also presumed that the flexors of the left thigh were weak because, even two years after the initial attack, she could only raise the extended leg two or three times before fatigue and cramp would intervene.

About a year later a young lady of sixteen, who had had two operations on the legs and feet, was found to have been made brace-free, with fairly good stability, but had a peculiar jerking hitch in her gait, which we found was apparently due to weak abdominal muscles. One day she was asked to walk for us with the abdomen exposed, and as we surmised, the umbilicus shifted its position as tension was made on the abdominal muscles. This (Beevor's sign) showed more markedly at every step and signified paralysis of a portion of the muscular wall. Every effort at moving the leg to make a step caused the umbilicus to be pulled upward and to one side. We noted also that when either leg was lifted the pelvic tilt increased, first to one side and then to the other, giving a twisting effect to the pelvic region, which accounted for the jerk in her gait.

Prolonged observation spurred our interest in making an effort to capture the remaining power in the partially paralyzed recti and obliques, when we observed the useless and ineffectual efforts of the remaining stable portion to transmit any force suitable, or sufficient, to obtain fixation of the front of the pelvis on the thorax. In our charting of the abdominal muscle strengths, we had previously been recording only the rectus anteriorly, quadratus lumborum laterally, and the obliques. Even then there seemed to be much question in the mind of the technician recording the tests as to what their real status was.

During a survey of scoliosis cases, conducted by Dr. Robert Carroll and myself, at the Orthopaedic Hospital in Los Angeles, we began to hunt for possible causes of scoliosis. We were strongly impressed by the probability that many were due to undiagnosed poliomyelitis, especially with those in whom obscure trunk muscle groups might have been partially weakened. For the previous three or four years, as cited above, my attention had been directed to the possible relationship of abdominal muscle involvement to spinal deviations. Consequently, we began at once to investigate all scoliotics not diagnosed as paralytic, for the existence of this phenomenon.

Finally, one severe paralytic scoliotic, for whom we had done seven operations over a period of ten years, and who could walk only with the aid of crutches, spine and leg braces, stated that she was willing and glad to have her abdominal defect repaired, which we did on July 17, 1931.

The operation consisted in opening the mid-line from two inches above the umbilicus to the symphysis, lateral dissection to uncover the rectus aponeurosis on the right side, which was opened and reflected, showing the attenuated remains of the paralyzed lower half of this muscle. A strip of fascia lata, obtained by another operator, was transplanted, extending from the lower two inches of the healthy upper rectus to the symphysis, into which it was inserted through an osteoperiosteal slot

raised from the bone. The strip, one inch wide and nine inches long, was sutured with silk above for two inches, then, with the operating table dipped in the middle to slacken the pull on the abdominal wall, the umbilical stem was grasped in strong forceps and pulled downward as far as possible, while the lower end of the strip was forced into the osteoperiosteal slot below and firmly sutured with silk. Sutures of silk were similarly placed on each side at intervals of an inch to an inch and a half; then the aponeurosis was laid back and stitched down with chromic catgut. Before further closing, another strip was fastened to the same location above and passed subcutaneously in the fat, downward and outward, to the right ilium at the point of attachment of Poupart's ligament, and attached osteoperiosteally as before, after all the slack, which would be allowed by the shortened upper left oblique, was taken up.

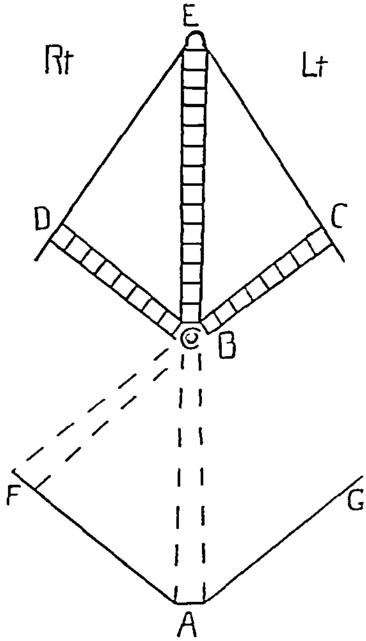

FIG. 1

Operation plan of first case, A. D., (See Fig. 2). Severe scoliosis in right lumbar region with pelvic droop on right.

This patient whose case was reported in the *New England Journal of Medicine* for December 17, 1931 (CCV, 1187), can now, almost a year after operation, stand without crutches for the first time in nine years, and is beginning to take steps without them.

The first case mentioned above was the second patient operated upon, and in her case the strips were put in from below upward. The upper rectus being the weak section, one strip went straight up to the rib margin and the other went outward to the opposite right costal border lower down, forming a Y attachment.

Referring to Figure 1, the diagram shows that the pull from point *E* to *B* will be transmitted through the new tendons to *A* and *F*, being split at *B*. Likewise the pulls of the upper oblique from *D*, and especially from *C*, will also transmit power via *B* to *F* and *A*.

In the second plan, the pull of the healthy lower rectus (Fig. 3) and the obliques will be transmitted through the new transplants from *A* to *D* and *E*, and slightly to *C*, via the weak remains of the upper left obliquus, while the strong oblique pull from *C* will also activate *BD* and *BE*, assisted somewhat by the force from both *AB* and *FB*.

As an illustration of the importance of the fixing and stabilizing effect of the abdominal muscles, these cases showed an immediate postoperative obliteration of Beevor's sign (*i.e.*, no movement of the navel, on head raising from the supine position).

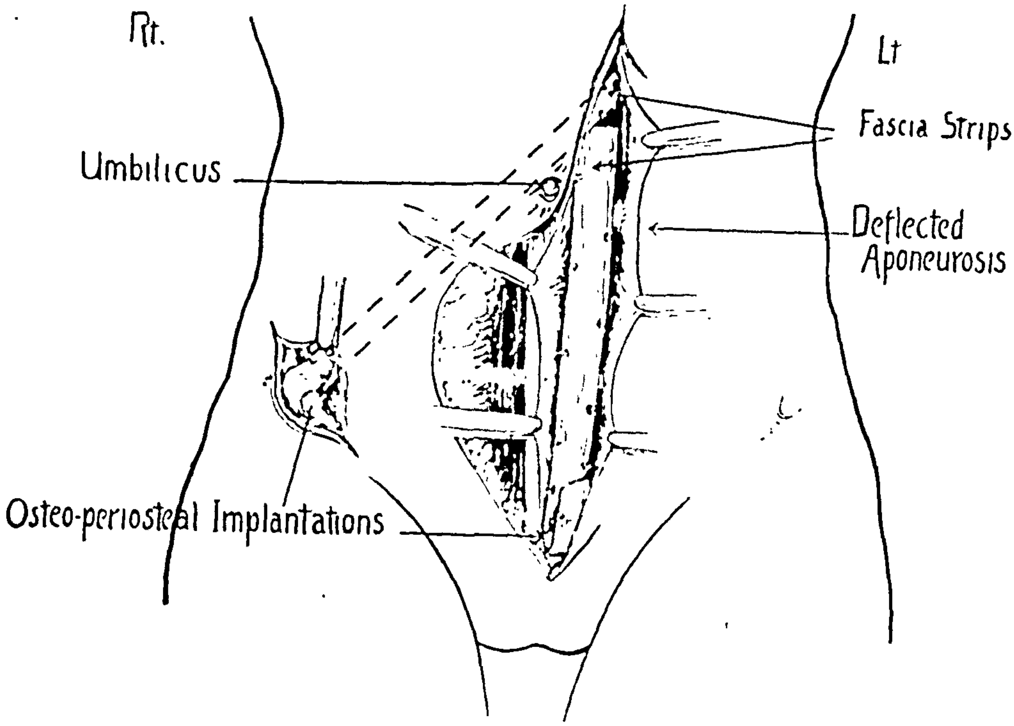

Fig. 2

Artist's sketch of first operation. Patient A. D.: paralysis of lower recti and right obliques. Fascial strip in sheath of left rectus and subcutaneous strip as fixation for healthy upper right oblique.

Case 2 further showed this stabilizing effect, by the fact that the weakness of leg raising disappeared. What we had supposed was weakness in the thigh flexors was actually not intrinsic psoas weakness, but weakness of the extrinsic stabilizers of the pelvis necessary for the proper action of the leg flexors at the hip joint.

We are quite convinced that asymmetrical influences of faulty kinetics do affect the spinal column in several ways, notably as follows:

1. Involved and relaxed rectus abdominis tends to produce forward tilt of the pelvis and lordosis of the low back, made worse when thigh flexors are active.

2. Unbalanced action of the quadratus lumborum induces lateral deviation in the lumbosacral region with secondary compensatory changes above. The latissimus dorsi may be similarly affected.

3. The transversalis, when strong and active on the one side and not balanced by its fellow on the opposite side, affects the lumbar section, and, in conjunction with quadratus imbalance, produces curvature and probably also rotation-deviation because of the pull on the lateral processes.

4. We feel that the presence of imbalances in the abdominal obliques, which are the stabilizers of the rib cage toward the mid-line, allows the rib cage to swing laterally until a point of fixation is reached, whenever arm and shoulder-girdle movements or leg and pelvic movements are made and thus, especially with asymmetrical influences, such as right-handedness and one-sided pull of the diaphragm (as noted by Jansen), a

rotary spinal deviation will be produced.

5. Whenever the serratus magnus is activated, as in forward pushing and reaching, it pulls upon its origin which, it will be recalled, is along the anterior rib margin where it interdigitates with the abdominal obliques. This pull, in the presence of droop shoulders and weakened rhomboids, plus the assistance of the pectoralis major, holds the weight of the shoulder, arm, and breast against the thoracic wall anterior to the angle of the ribs, and has a flattening effect on the side of the chest wall.

As the pull of the serratus is from in front and below, upward and backward around the side, it must of necessity have some stabilizer in order to be effective,—*i. e.*, the thorax must be fixed at the point of origin where the force applied will move the base of action instead of the shoulder. The chief opponents of this pull are the abdominal obliques and opposite transversalis. The rib margin is stabilized against side twisting by the broad upper obliques which insert into the rectus aponeurosis and the linea alba, and this structure is fixed by the opposite lower obliques and transversalis to the opposite ilium.

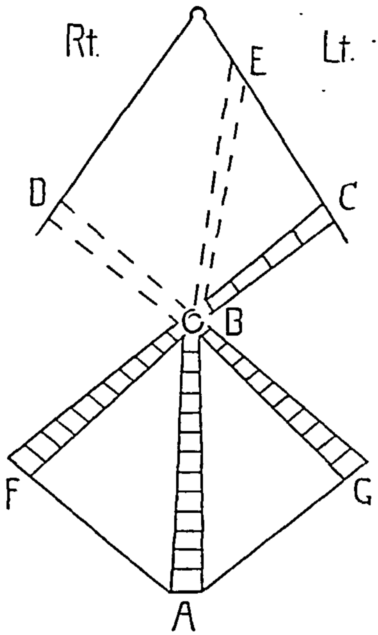

FIG. 3

Operation plan of second case, E. C. Strip *EB* within upper left sheath. Osteoperiosteal insertion through two split rib margins. Strip *DB* subcutaneous stabilizer for right serratus and lower left oblique and transversalis. Progressive right dorsal scoliosis starting during recumbency period.

If the integrity of this diagonal pull is interfered with, the rib cage will swing laterally under the pull, until some point of fixation is reached. Now if the upper or lower half of the rectus abdominis is paretic or paralyzed, or if the upper oblique on one side, or the lower oblique on the opposite, is likewise involved, either or all of them, separately or together, the stabilization of the rib cage on the pelvis cannot be attained. In consequence, unopposed muscles with diagonal or lateral pulls, like the transversalis, serratus magnus, abdominal obliques, together with asymmetrical action of the unbalanced pull exerted by the pectorals, especially the minor, latissimus dorsi and quadratus lumborum will contribute materially to spinal and costal deformation.

The chief factors in the production of scoliosis, other than hereditary congenital faults, are:

1. Gravity pull.
2. Skeletal asymmetries, such as short leg, or pelvic discrepancies of development.
3. Structural alteration of muscle action.

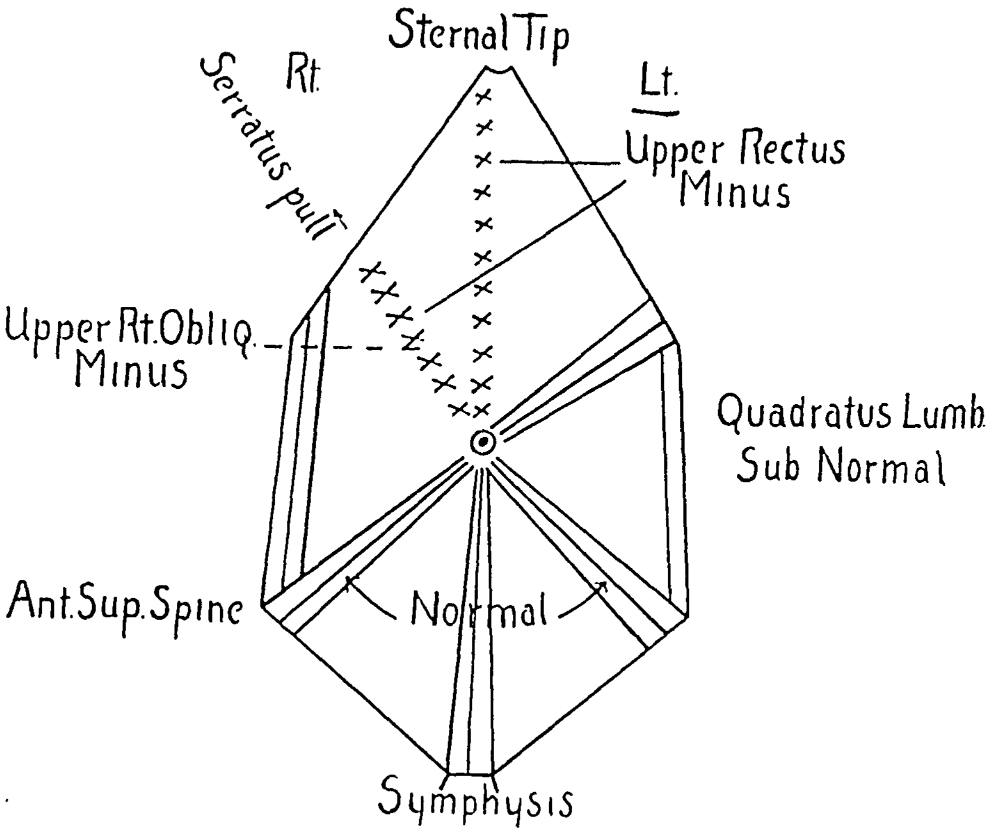

Fig. 4

Muscle chart, preoperative record of second case operated upon, E. C. ||| = normal. || = moderately active. | = active but weak. xxx = inactive. (See Fig. 3.)

In all cases some degree of each of these causative factors exists, but in paralytic scoliosis in the growing child, the last mentioned is usually the initial cause, which allows the force of gravity, acting in a wrong direction, to influence the skeleton, and then the second factor becomes more and more an influence as asymmetries of skeletal growth occur.

Due to the fact that we have seen both lateral and rotary spinal deviation initiated in children previously straight, during the stage of recumbent treatment following an attack of poliomyelitis, in which instance gravity pull can be ruled out, as can also be growth faults, which are only an influence in sitting or in the erect position, we must conclude that the unbalanced action of unopposed muscle pulls is the factor which, in many instances, initiates the deformity. For instance, in a boy five years of age, previously straight, a curvature is developed, even though he was recumbent for a year, and the only affected muscles were the upper half of the abdominal muscles and a moderate involvement of the shoulder girdle.

This same condition existed in the first case mentioned in this paper, an older child, in which instance, the condition progressed despite recumbency over a long period, braces, traction, casts, etc. under the best conditions of cooperation and skilfull treatment (See Figure 3).

The rotary deformity is particularly influenced by the unbalanced action of the serratus when its extrinsic fixators are involved. Right-

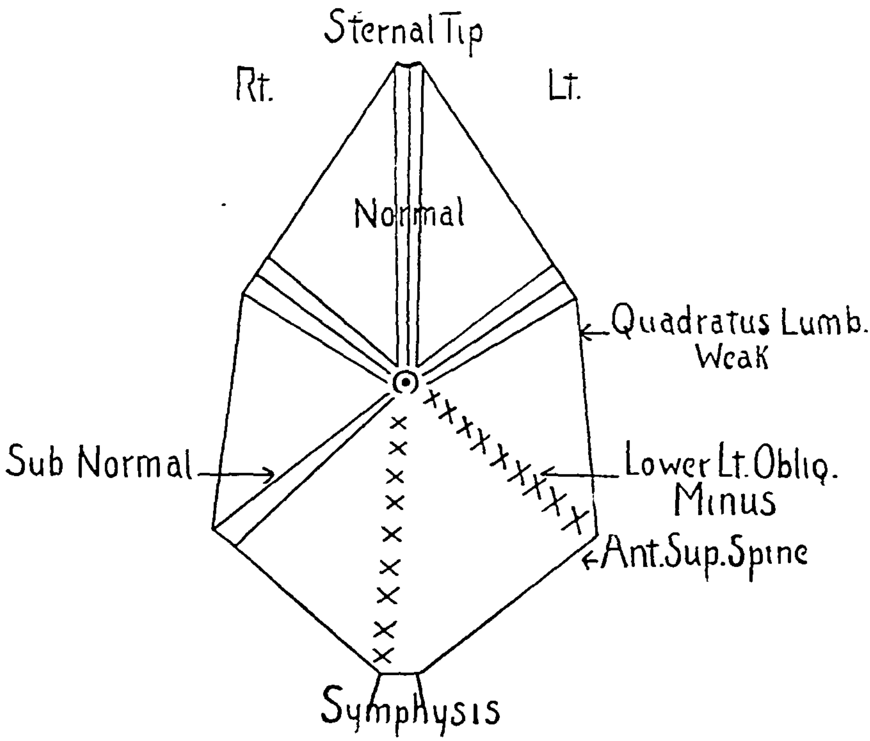

FIG. 5

Diagrammatic muscle check, postoperative, of G. E., fourth case. Marked lower trunk weakness, absent lower left obliques and lower half recti. Only slight scoliosis.

handedness, plus the continuous asymmetrical action of the diaphragm in breathing (if we accept Jansen's observations in this connection), plus these other factors which become effective as soon as the upright position is assumed, must be regarded as contributory.

We have found, upon close observation suggested by this study, that our previous tests of the strength and integrity of the abdominal musculature were too limited to show up the actual conditions which exist in such cases. Consequently, in testing, we have discovered the following movements useful in determining the presence of involvement of the abdominal wall, and the presence of its weakness or paralysis:

1. a. Raising the head forward from supine position.

b. Raising head forward against resistance to forehead,—a test of the recti, chiefly.

2. Straight arm push from recumbent position forward from shoulder against resistance, noting the action of obliques, to test serratus magnus.

3. a. Leg raising, each side without, or with, assistance.

b. Against moderate resistance. This tests obliques and rectus in relation to hip flexors.

4. Leg pull up, or hip raising against resistance. This tests quadratus lumborum and, somewhat, the latissimus dorsi.

5. Starting to roll over. This tests transversalis and obliques in relation to mid-line stability of rectus or opposite muscles.

6. a. In the water, prone and supine "jack-knife" exercises,—*i. e.*, lying supine, sinking the hips and bringing shoulders and knees toward each other.

b. Prone, sinking the shoulders and knees and raising pelvis out of the water. For positive findings one will note the presence in varying degrees of the umbilical movement sign, with its displacement toward the strongest muscles. In the presence of total paralysis, or normal muscles, there will be no movement of the navel.

7. Another test is also used to note the area of weakness. The patient takes a big breath, presses down on the diaphragm and tries to balloon the abdomen. In total paralysis it can be greatly distended without any feeling of muscular resistance to the palpating hand; or, if limited areas are weakened, they will protrude to a greater distance than the surrounding area and there will be diminished resistance of the wall over the region affected.

8. For localizing action of opposite obliques, a good test is as follows: supine lying in water, arms extended upward in form of a Y, legs half abducted, the opposite arm and leg are raised. This tends to twist the body and is a pure test of oblique fixation.

We have noted some cases of scoliosis of the structural type, previously undiagnosed as to cause, to show this phenomenon, as well as a positive umbilical sign, when there was nothing in the history to lead one to suspect a paralytic origin. The importance of such differential diagnosis lies in the fact that the progress is graver and the treatment more difficult in the paralytic cases.

Whether or not this plastic repair of the abdominal wall will have a corrective influence on scoliosis after the other factors are added, we cannot as yet say. However, we feel justified in reasoning that a scoliosis with rotation-deviation occurring in a straight child, during convalescence in recumbency, and in whom partial paralysis of some sections of the abdominal musculature is the most notable involvement, must have local muscular paresis as a causative or contributory influence through muscle imbalance.

If we wait until curvature develops and then fuse the column we will in no way alter the kinesiological imbalance of these important muscles. On the other hand, since repair of the defect has greatly improved even some old chronic scoliotic cases, we feel certain that its early repair will give much help to the early ones and will probably have a decidedly preventive influence on the deforming forces. We also feel that early recapture of the wasted power of the remaining viable portions of the muscles, by the means described, may greatly aid in preventing the advance of the condition to as extreme a degree as it might otherwise progress.

The procedure is somewhat tedious but in no way technically difficult; it requires no great depth of anaesthesia and is attended by little

danger to the patient. The postoperative treatment is simple, needing only a semirecumbent position in bed for three weeks, after which sitting in a wheel chair may be allowed. Early movements in the water give an excellent method of beginning reeducation to the muscles and put physiological strain on the new tendons without gravity load. They are begun as early as twenty-one to twenty-four days and continued, with gradually increased load, until all danger is passed. Walking in deep water is begun at four to five weeks, and then walking as before.

Twelve cases have been operated upon to date, some too recent to record, but our physiotherapists report all progressing satisfactorily. Those done more than six months ago, however, show increasing power and apparently heavy, palpable cord-like development of the fascial tendon, with a much greater sense of the support to the abdominal organs. They all seem improved in general, out of proportion to the local benefit anticipated. This general improvement may readily be due to added support given the abdominal contents and from preventing visceral drag on vessels and nerves. The first patient operated upon has recently stated that she feels more benefit from this procedure than from any of her previous eight operations. Her father, who is a physician, stated that she can sit longer without fatigue, handle her body with greater facility, and shows a renewed interest in everything being done for her. She has begun to take steps without crutches for the first time since she was stricken nine years ago. We have, in the case of girls, placed these fascial strips only from the umbilicus up or down with the idea that ultimately they would be no obstacle to pregnancy. However, in two cases, one done in January and the other in April, 1932, one boy and one girl, with severe lateral lists of the trunk on the pelvis, strips were run from the iliac crests to the umbilicus on one side below and from there to the rib margin on the opposite side above, to act as diagonal tethers. The boy is now able to sit up and hold himself in mid-position without the tendency to list to the left as before the operation and walks much better. In the girl a much improved control is reported and the abdomen is more stable, although at this writing she has not as yet started to walk.

SUMMARY

1. The recapture of lost power in the presence of partial paralysis of the abdominal muscles is possible and practical.
2. Decided improvement in stabilization of trunk on pelvis is obtained.
3. There is a specific relationship between abdominal paralysis and paralytic scoliosis.
4. The corrective or the preventive possibilities of this procedure cannot as yet be definitely stated, but, if such a relationship is recognized, specific benefit of this nature ensues.

SUMMARY OF DISCUSSION

Dr. W. B. Carrell, Dallas, Texas, does not believe the work can be treated as a permanent result, but if it holds as well as it looks, it should be of benefit.

Dr. Arthur Steindler, Iowa City, Iowa, refutes the idea held by some that paralytic curvature develops only when patient is erect and that gravity is against function. Gravity is used at times to combat deforming tendencies, but rotation is a tendency it cannot control. It is common observation that, where the great rotators of the spine are lacking, curvature will develop during recumbency. Of these rotators the external oblique is one of the most important. When the serratus magnus is weak, it will rotate that side backward; while the external oblique, the dominant rotator of the abdominal muscles, will act in an opposite fashion on the same side. In spite of lack of elasticity and contractility of the fascial strip, Dr. Steindler thinks it affords a firm support between the costal arch on the paralyzed side and the opposite iliac crest.

Dr. W. E. Gallie, Toronto, concurred with both Dr. Carrell and Dr. Steindler upon the ingeniousness of Dr. Lowman's method of operating, but felt that time must elapse before it would be safe to draw any definite conclusions as to its value.

Dr. Lowman, in closing, cited three of the cases in which these principles had been followed out, one a bad case of muscular dystrophy.

CEREBRAL BIRTH INJURIES: THEIR ORTHOPAEDIC CLASSIFICATION AND SUBSEQUENT TREATMENT *

BY WINTHROP M. PHELPS, M.D., NEW HAVEN, CONNECTICUT

Professor of Orthopaedic Surgery, Yale University

The classification of cerebral birth injuries has always been made on a neurological basis. Lesions are described as occurring in various parts of the brain. The mechanism of production of these lesions has had much careful study. The remote causes have been considered and include such factors as prematurity, primiparity, icterus neonatorum, congenital syphilis, dystocia, and obstetrical difficulties. Classifications, distinguishing the actual birth-injury group from congenital anomalies of the nervous system, have been made. All of these studies have aroused the interest and cooperation of the obstetricians in an increased effort to prevent the injuries, in many cases unjustly attributed to them. Nevertheless, children continue to suffer from this type of dyskinaesia, whatever the cause, and treatment must be carried out. An exact definition of the term "cerebral birth injury" would strictly imply only an obstetrical injury, but the late results of many types of disturbance to the child during the last month of pregnancy and the first two or three weeks of life are, in many instances, identical with actual obstetrical damage. Hemorrhage in the cranial cavity, which is the most common cause of the types of dyskinaesia to be described, will produce the same picture, whether or not it is the result of actual obstetrical injury. Therefore, as the types of dyskinaesia come naturally to the orthopaedic surgeon for treatment, all being crippled in one way or another, a classification must be made, which can be used as a basis for treatment. Such a classification must be made on a functional basis, and must take into consideration the total function of the individual, rather than that of an arm or leg alone. Total function includes, of course, both mental and physical ability.

Little[1], in 1862, described these cases first in an article bearing the following title: "On the Influence of Abnormal Parturition, Difficult Labors, Premature Birth, Asphyxia Neonatorum, on the Mental and Physical Condition of the Child, Especially in Relation to Deformities". For years, Little's disease covered the whole group, of which a typical example was the feeble-minded, drooling child, with scissors gait and marked general spasticity. But further study has shown that there are many physically handicapped types, with or without mental deficiency. These individuals may often be wrongly classified as mentally deficient, because of lack of motor control of the facial muscles, or physical inability to speak or perform the usual intelligence tests. Therefore, it is important to determine the mental level in these cases as accurately as possible.

* Read before the Section of Orthopaedic Surgery, New York Academy of Medicine, January 15, 1932.

while allowing for the physical handicap. A recent survey of a large feeble-minded institution* has shown approximately six per cent. with motor disturbance and a definite history of birth injury. It is probable that actual mental deficiency is not present in some of these, but that retardation has resulted from environmental difficulties. Study of mental level evaluation in children showing physical handicaps is showing, more and more, that there is behind the mask of dyskinaesia a trainable mind in a large percentage of the birth-injured.

Confusion in late diagnosis of these conditions is certain to occur because of the many acquired physical handicaps which resemble closely, at first glance, the birth-injury group. It is not sufficient to classify these cases as "spastics" or as "Little's disease". Treatment obviously will be of no avail, even in the group in which the mentality is good, if the lesion is progressive. Many cases of epidemic encephalitis result in a physical handicap which is identical with certain types of birth injury and, if the history is not available, a differential diagnosis is difficult. However, most, if not all, of the postencephalitic group show a progressive picture and observation over a period of time will demonstrate this fact. The same is true of Wilson's disease. Confusion arises also in cases of congenital anomalies of the central nervous system, especially in regard to the diplegic group, described by Ford, Crothers, and Putnam.[2] If there is the slightest tendency toward an asymmetrical distribution, the cases are regarded as probable birth injuries, all other factors being equal. Slowly growing brain neoplasms may also occasionally be confused with birth injuries, but in these cases their progressive nature soon becomes apparent.

Having determined that the intelligence is sufficiently great to make treatment worth while, and that the lesion is static and not progressive, the exact type of dyskinaesia must be studied, in order to carry out a rational form of treatment. Originally, all cases not showing flaccid paralysis, as in poliomyelitis, were grouped as spastic. Later, it was seen that some showed a predominance of incoordination and uncontrolled movements, and the group was divided into those with spasticity and those with athetosis. Further study of the motor disturbances demonstrates that there are many varieties of dyskinaesia, which, in order to carry out rational and intelligent therapy, must be distinguished and treated as entities.

There are two chief methods of study of these disturbances. In many cases, the movements are too rapid to be caught by the eye, but the use of slow-motion pictures will reveal the difficulty exactly. The second method, which will only be mentioned at this time, is the laboratory procedure of oscillographic records of muscle-action currents. Much information can be gained concerning rate of contraction, sequence of contraction, shape of curve, etc. As a result of these two methods, definite entities become observable. These may be considered under five

* The Training School, Vineland, New Jersey.

main headings,—namely, (1) Spasticity, (2) Athetosis, (3) Overflow or Synkinaesia, (4) Incoordination or Ataxia, (5) Tremor. It is significant that these practically never appear in pure form, but rather one type will dominate the picture, with evidences of other disturbances present to a lesser degree.

1. *Spasticity.*

Spasticity represents a hyperirritability of muscle to any stimulus. Tapping on the patellar tendon produces a markedly increased violence of contraction of the quadriceps. But any stimulus will likewise produce this contraction. Clapping the hands loudly causes sudden response, or any local disturbance of the muscle, such as rubbing or striking. Stretching the muscle is, of course, a distinct stimulus to contraction. This is seen especially on attempted passive motion. The muscles seem to resist the pull, which is clearly the result of the stimulus to contraction caused by the attempted passive motion. The typical disturbance in the spastic individual is thus explained. For example, the patient voluntarily attempts to flex the knee by contracting the hamstrings. The motion of the knee in the direction of flexion tends to stretch the quadriceps extensor. This stimulus causes a contraction of the extensor reflexly. Therefore, the result is a contraction (voluntary) of the flexors, almost simultaneous with a contraction (reflex) of the extensors, resulting either in no motion at all or markedly impeded motion. This mechanism becomes obvious in the slow-motion picture. Spasticity, therefore, is dyskinaesia found in muscles which are hypersensitive to contractile stimuli and in which voluntary contraction of a given group produces reflex contraction in the antagonistic group.

2. *Athetosis.*

A study of the literature brings to light an extremely confused picture. Many use the word interchangeably with choreiform movements, incoordination, etc. An attempt to determine this condition as an entity is greatly simplified with slow-motion pictures. It is seen as an involuntary, more or less constant contraction of successive muscles, without regard to function in antagonistic or reciprocal groups. It may be rapid or slow and is not affected by voluntary contraction. When voluntary contraction is willed, it becomes superimposed on the athetoid movement, the result resembling closely other forms of incoordination. Careful observation of the films will show definitely this superimposition. Athetosis, then, can be defined as involuntary motion of unrelated muscles which produces incoordination as a result of superimposed normal voluntary contraction.

3. *Overflow or Synkinaesia.*

Overflow represents another separate entity of dyskinaesia. It is involuntary motion resulting from voluntary attempts at motion. It is an example of the difference between neurological and orthopaedic classifi-

cation. For overflow is often not a pathological neurological entity. Very little is known about it, yet it is very important therapeutically. Overflow is seen as motion of the legs or feet, on attempts at voluntary motion of the hand or arm. It is seen as involuntary motion of the hands on attempted use of the legs. The overflow may be limited to the face on use of either the arms or legs. The degree of overflow varies within wide limits. It is seen in normal individuals occasionally. Sticking out the tongue or grimacing while writing or untying knots represents a more or less normal overflow reaction. The amount of overflow usually increases with the difficulty or complexity of the motion. It may be associated, therefore, with any form of dyskinaesia. Severe facial overflow frequently causes the patient to appear feeble-minded because of the grimaces on attempts to walk or use the arms. It is misleading, especially when it results from voluntary attempts at speech, but it is more important from a therapeutic view-point when it occurs in the arms or legs and interferes with motor control.

4. *Incoordination or Ataxia.*

The term has been used to describe so many different entities that it is probably inadvisable to use it unmodified. In the discussion of athetosis, for example, it was seen that incoordination resulted from the superimposition of normal voluntary efforts upon athetotic motion. This would differ markedly from voluntary incoordination. Voluntary incoordination would be represented by the inability to direct movement in the desired direction. Again, careful observation aided by slow-motion pictures will identify this entity. It is seen in its pure form in the ataxias and is to be distinguished especially from athetosis and overflow. Incoordination, thus resulting when a voluntary effort is made to perform a given motion, may result from a variety of causes, which include loss of muscle sense, loss of equilibrium, etc., or, more rarely, interference with muscle balance of peripheral nerve or muscle origin. Passive incoordination represents such combinations of conditions as result from athetosis and voluntary effort, but can be reduced to more fundamental difficulties.

5. *Tremor.*

Tremors can be classed as fine or coarse, and as intentional or non-intentional. There is no confusion concerning this type of dyskinaesia, except in cases of very coarse intention tremor where the condition suggests an incoordination. It can be distinguished, however, by its rhythmical and recurrent nature.

The five above entities or varieties of dyskinaesia are those which are found in birth injuries or in conditions which are likely to be mistaken for birth injuries. Other varieties of disturbance of motor function are usually well defined. Chorea may be mistaken for a fairly rapid athetosis. Choreic motions are spontaneous, involuntary motions, not constant in character but presenting a much more definite pattern than athetosis.

These motions are so rapid that they often appear purposeless. If they are slowed down by means of a slow-motion picture, the pattern becomes obvious in nearly all cases. In athetosis this is not true. Habit spasms or tics are not likely to be mistaken for other conditions. Convulsions are usually unmistakable, although in severe cases of athetosis a momentary impression of a convulsion may be given. Decerebrate rigidity needs no comment here.

The five varieties of dyskinaesià described seldom occur in pure form. They are seen combined in various degrees and must be distinguished in every case. The relation to attempted voluntary motion must be carefully studied with the idea of therapy in mind. The aim of the whole orthopaedic study is to supplement the neurological diagnosis in such a way as to determine the practicability and advisability of treatment. It is for the same reason that the orthopaedic surgeon must make, or have made, a careful evaluation of the mental status. This cannot be done successfully without a clear understanding of the physical handicap, involving, as it may, the muscles of speech and face. Of course, many other factors, social and individual, must aid in determining the practicability of treatment, as many years are necessary to bring about satisfactory results and interruptions of treatment during this time frequently cause loss of all previous benefit.

Having completed the study of dyskinaesia, it is necessary, especially in older individuals, to determine the habit factor which is complicating the picture. The ability of these patients to perform their daily routine acts is sometimes extraordinary, but these acts are carried out in bizarre ways which have been stumbled on and which, when repeated, become habits. One patient with only a mild athetosis could only pick up objects from the table with his back to the table. When much younger, he had found that he could do this, and always afterward he repeated it. After a very short period of treatment, he was trained to accomplish this act in the usual way. The result was very great in his general welfare, as he could eat at a table after this and his social life consequently was much simplified.

The presence of any actual contractures must be determined. In the spastic type, apparent contractures are often mistakenly operated on. The toe-walking due to extreme spasticity of the gastrocnemius-soleus suggests contracture, but, in the examination, care and patience will prove that the foot often may be dorsiflexed the full amount. Real contractures are seen most frequently in the knees, but here again the joint may often be fully extended slowly. The adductors are often tenotomized unnecessarily, thus preventing any normal power of adduction later. The same general principles hold for the arm.

A study of the muscle balance must be made. Hyperactivity of one group as compared to another should be noted for therapeutic reasons. This is most strikingly seen in the abductor-adductor hip antagonists in the spastic group. The "scissors gait" seldom actually represents a

contracture, but the power of the adductors, being normally greater than that of the abductors, results in this position when both groups are spastic. It is, therefore, more difficult for these patients to perform abduction than adduction.

TREATMENT

1. *Relaxation. Primary Treatment.*

The principles are based on the actual difficulties found in the examination. In the spastic, the hyperirritability of muscles, resulting in almost simultaneous contraction of antagonists, is the important factor. Thus, voluntary relaxation should be one of the first aims. In the athetoid, voluntary relaxation is desirable in order to produce volitional motions later, uncomplicated by athetoid movements. The abolition of synkinaesia or overflow can only result from relaxation as a first principle. In pure incoordination, the principle of relaxation is less important, as is the case with tremors. The ability to relax is important to normal individuals. It relieves tension, mental and physical, and is essential in skilled activities. This is stressed in sport. Golfers are constantly adjured to relax. Skilled musicians must keep the body relaxed while playing. In the birth-injured, its importance is very great, and it can be taught successfully if cooperation can be obtained. In babies and youngsters, relaxation is a more normal finding and here it is taught to be maintained in the presence of more and more disturbing factors. The clap of the hands will throw many of these into spasm, but a process of conditioning will result in much benefit. In older children and adults, of course, it can be taught more directly. This part of the treatment should precede all other forms and should last until relaxation can be instituted at will and maintained at will for a long time. Aids to relaxation should be used with caution and, when used, the reason must be kept clearly in mind. Warm baths, sedatives, etc., are the chief aids. But there is great danger of bringing the patient to depend on these aids and to be unable to relax without them. The whole aim of the treatment is thus vitiated as the relaxation is obtained, but is no longer voluntary. Massage may be of help; it should be tried. In some cases the effect will be beneficial and in others it will be an irritant.

2. *Treatment of the Neck and Trunk.*

In patients who cannot stand, sit, or balance, and who have difficulty in holding up the head, general training must be started on the trunk and neck. The head can often be held up more quickly if a Thomas collar is worn for a time and muscle strengthening given daily for the neck. The collar acts to limit the extreme overstretching which results from the head falling in any direction whenever the patient is lifted. Massage and strengthening exercises of the usual type are used for the neck and back muscles, and balance is gradually attained, in the sitting position, by daily practice beginning with assistance. Often the patient will learn to balance much more quickly while wearing the Thomas collar because of

the stabilization afforded the head. The work on the extremities, most of which is done lying down, can be begun simultaneously with the strengthening of the neck and trunk.

3. *Reciprocal Motion. Treatment of the Extremities.*

Treatment should always begin with the proximal joints. A highly trained hand or foot is of no use if there is marked dyskinaesia in the shoulder or hip. The work should begin with these joints and extend gradually to the more distal parts. Often a year or more is necessary on the hips and shoulders alone, and at the end of this time very little improvement will be actually apparent. This must be stressed in the treatment, especially to relatives. The length of treatment, of course, is great,—five years usually being the minimum.

As has been seen, the inability to carry out reciprocal motion results from a variety of different causes. In spasticity, it is due to the reflex contraction of the antagonist on attempted voluntary contraction of the protagonist. In athetosis, it is due to the distortion produced by the underlying athetoid motion when a volitional motion is superimposed. In incoordination, it is due to the inability to direct the motion itself, either through loss of joint sense, as in tabes, or loss of equilibrium, as in cerebellar lesions, or through local muscle imbalance. There is less difficulty with reciprocation in overflow or in the various tremors. The reestablishment of reciprocation must depend on an understanding of the particular disturbance in the individual case.

In spasticity, the previous training in relaxation is basic. Then, while in as complete relaxation as possible, minimal passive reciprocal motion may be attempted. These motions should be of very small amplitude and be carried out very slowly, in order not to disturb the relaxation or produce reflex spasm. Later the motion should become active assisted motion. The amplitude should remain small, the rhythm be marked, and the speed of reciprocation slow. No attempt should be made to emphasize the motion in one direction more than another. Thus, if the patient is a spastic and the motion being given is abduction-adduction of the hip, the greatest pull is in the adductors, because of their greater strength. If the motion toward abduction should be emphasized, the tendency to resulting spasm in the adductors will be increased and the treatment vitiated. Therefore, the motion should be balanced in amplitude, speed, and rhythm. Some method of eliminating gravity must be used. The exercises may be given with the patient supine on a polished board, covered with talcum, or they may be given under water. Finally, active reciprocal motion may be begun by the patient himself, when it has been demonstrated that it can be done without spasm. Gradually the amplitude of motion can be increased and, much later, the speed increased. Rhythm must always be kept constant and should be equal in both directions. Passive stretching in spasticity is always entirely useless.

In athetosis, the essentials are somewhat different. Here, the athetoid movements underly essentially normal reciprocation. If the athetosis is pure, the *training in reciprocation can proceed more rapidly*, but the preliminary training in relaxation will be found to take a much longer time. The work is begun as passive reciprocal motion, carried *through active assisted reciprocation to active reciprocation*. The amplitude of the motions can be increased more rapidly than in the spastic and the rhythm must be very regular. The speed should only be increased very slowly.

In overflow or synkinaesia, the work is again different. Here, the passive reciprocal motion will be easy, as the overflow only results from attempts at active motion. The treatment, therefore, will emphasize the stage of active assisted reciprocation, and this phase will be the longest. Here, the amplitude and speed must be extremely slow, as any attempt to hurry will produce a recurrence of the difficulty.

In incoordination of the pure type, the training in reciprocation resembles closely the training for any skilled activity, as in sport. But, again, it should be begun cautiously. If joint-posture sense is absent, then there is no point in passive reciprocation, and training can be begun directly with the active phase. In cerebellar lesions, the passive phase is necessary, but of shorter duration than the assisted and active phases.

In tremors, there is very little to be accomplished when they are of the non-intention type, but, in the intention tremor, reciprocal exercise is often very effective. It should be emphasized again here that these conditions represent static lesions, the progressive ones having been eliminated, and that the attempts at controlling intention tremor are thus more successful.

The conditions described seldom occur in pure form, but one or another predominate in a given case. The reciprocal motion must be given according to the indications of all of the conditions found in the individual under treatment. Thus an athetoid patient with overflow will necessitate taking both of these conditions into consideration. Any element of spasticity seen in an otherwise athetoid patient must also be given special attention according to the principles of the treatment of spasticity. This brief summary of the use of passive, assisted, and active reciprocal motion illustrates the necessity for orthopaedic classification of these patients.

The indications for surgery should never be immediate. A period of training is often productive of surprising results, making certain operative procedures unnecessary. In any case, the procedures should be used only as incidents in, and aids to, the training program. A conservative attitude should be adopted. (a). *Tenotomies are usually unnecessary* as the results are irreparable. They can occasionally be used to reduce total power where one of a group is tenotomized. For example, the adductor longus, when tenotomized alone, leaves the pectineus, adductor brevis, and adductor magnus to perform the motion. A better balance may be

obtained in this way. (b). Tendon lengthening is not usually necessary or advisable, as the muscle will sooner or later contract sufficiently to produce the same deformity. However, it cannot be said that it should never be used. (c). Tendon or muscle-stripping operations are used essentially to give better contractile leverage. Thus, the Soutter operation will decrease the mechanical advantage of the rectus femoris and sartorius, and consequently increase the mechanical advantage of the hip extensors. Training in hip-extension motions may thus be facilitated. (d). Novocain injections of nerve trunks are used occasionally to determine the effect of throwing them temporarily out of function. There may be doubt occasionally about the advisability of alcohol injections or Stoffel operations. A preliminary novocain injection of the nerves in question may be of great help in this determination. (e). Alcohol injections will throw a muscle or group of muscles out of function for a period of months by the paralysis of their motor nerves. This may be desirable in order to facilitate a period of training of the antagonists so that, when power returns to the paralyzed group, a balance can be effected. (f). Stoffel operations are valuable aids to the treatment. These procedures cannot be expected to effect a cure, but, in carefully selected cases, will enable a balance of power to be brought about which results in much greater ease of training. The most common nerves used in this procedure are the branches of the obturator and of the internal or external popliteal. Of course, the procedure may be applied to the nerves of any desired muscles. (g). Sympathetic ramisection has not proven of much value. In those cases showing the "plastic rigidity" described by Hunter and Royle, it is occasionally of benefit. (h). Tendon transplantations may very occasionally help in improving balance.

4. *Advanced Treatment.*

The further treatment, when relaxation and reciprocation have been established, consists of combining motions which have been learned into action patterns. At first, it is wise to combine only two simple motions, such as hip and knee flexion, or bilateral abduction-adduction of the legs, or elbow flexion with supination. As these combinations are learned, more combinations may be added. Motion under weight-bearing gives rise to difficulties due to reflex stimulation of muscles by gravity. Thus, the motions of walking may be learned perfectly lying down and no change in the gait observed in walking. Here, the gravitational effect has not been simulated in the treatment. It can be thus simulated in the treatment by making resistance to the motions while they are being learned and the results are gratifying. The best form of record of improvement is the motion picture record, taken at definite intervals. It is impossible to remember the performance from year to year, but a comparison of films will show the rate of gain, and act as a guide to further treatment.

It may be seen, therefore, that the treatment described is not easy.

and that it covers a long period of time. It requires the careful study of the individual from all standpoints,--mental, physical, and social. The cases which are accepted for treatment require very constant care. The treatments should constitute a regular part of the daily routine and the average length of time is an hour a day. The rest of the day, the condition should be forgotten. Patients become "stale" as in too prolonged or constant training for any reason. It is advisable to skip one day a week and to allow about a month's vacation each year. Greater advances will be made by this method. The greatest gains can be made only if these patients are institutionalized. There are very few institutions at present with facilities for handling the mentally normal, birth-injured individuals. It is hoped in the future that more will incorporate these facilities and that more institutions for the care of these patients will be available.

SUMMARY

1. Cerebral birth injuries are described and the handicaps, both physical and mental, classified from an orthopaedic rather than a neurological point of view in order to facilitate therapy.

2. A neurological diagnosis is nevertheless essential in the survey of the patient in order to rule out other conditions which may be progressive.

3. A careful mental capacity evaluation must be made, taking into consideration the physical handicap as an added factor in determining the advisability of treatment.

4. Treatment is briefly outlined for the various types of dyskinaesia.

5. The use of slow-motion pictures is recommended as a great aid in distinguishing the various types of dyskinaesia encountered and as an aid in recording improvement.

6. Slow-motion pictures were shown illustrating the types described and comparative films as used for record.

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THE PNEUMOGRAPHIC METHOD OF RECORDING GAIT*†

BY R. PLATO SCHWARTZ, M.D., AND ARTHUR L. HEATH, ROCHESTER, NEW YORK

In justice to those who have been responsible for the progress of orthopaedic surgery up to the present time, we should consider its needs for corresponding advancement in the future. Let us illustrate by a comparison with the development of other phases of medicine.

The leaning tower of Pisa recalls the unchastened spirit of Galileo[1] leaving the University to become professor of mathematics at the University of Padua in 1592. That which probably represents the first alcohol thermometer was the result of his initial efforts in his new position. Although evidence is scarce, it suggests that nearly two hundred years elapsed before the recording of body temperature was made possible through the development of the mercurial thermometer by Fahrenheit [2,3] about 1714. The Vienna school of medicine began to flourish, under the influence of van Swieten[4], about 1750. It is recorded that he first placed the clinical thermometer in the mouth of medicine amidst criticism which was softened only by the favor of Maria Theresa and Joseph II. Fever continued to be regarded as a disease until Lord Kelvin [5,6] established the "absolute scale of temperature" in 1848 and Wunderlich [7,8] founded clinical thermometry in 1868. More than two hundred and fifty years were required for the accepted application of physical laws to the measurement of body temperature. The value of this procedure is now so generally accepted that every layman anticipates this common practice to be employed by his family physician.

Since 1903, and later in 1906, when Einthoven [9,10] first revealed the possibilities in Leyden, the work of Mackenzie [11,12] and others has been enlarged upon by the use of graphic records for the study of cardiac function. The electrocardiograph has become a part of the equipment essential for the best treatment of heart disease.

There are many other examples, but these must serve to emphasize the fact that measurement is essential for the interpretation of normal and abnormal phenomena of the human body. Empiricism, fostered by trial and error, must continue to govern the therapy of abnormal function until measurement in some form improves the treatment of disabilities affecting the back and lower extremities.

The historical account of the study of gait is, like other subjects in medicine, interesting and lengthy. "Animal spirits" activated the extremities in the time of Aristotle [13,14] (384–322 B.C.). It is said that his grandson Erasistratus [15,16] (310–250 B.C.) first discovered that muscles had the property of contraction.

* From the Department of Surgery, Division of Orthopaedics, Rochester University School of Medicine and Surgery. Funds for this research work have been provided by the Rockefeller Foundation.

† Read before the University of Rochester Medical Society, May 9, 1932.

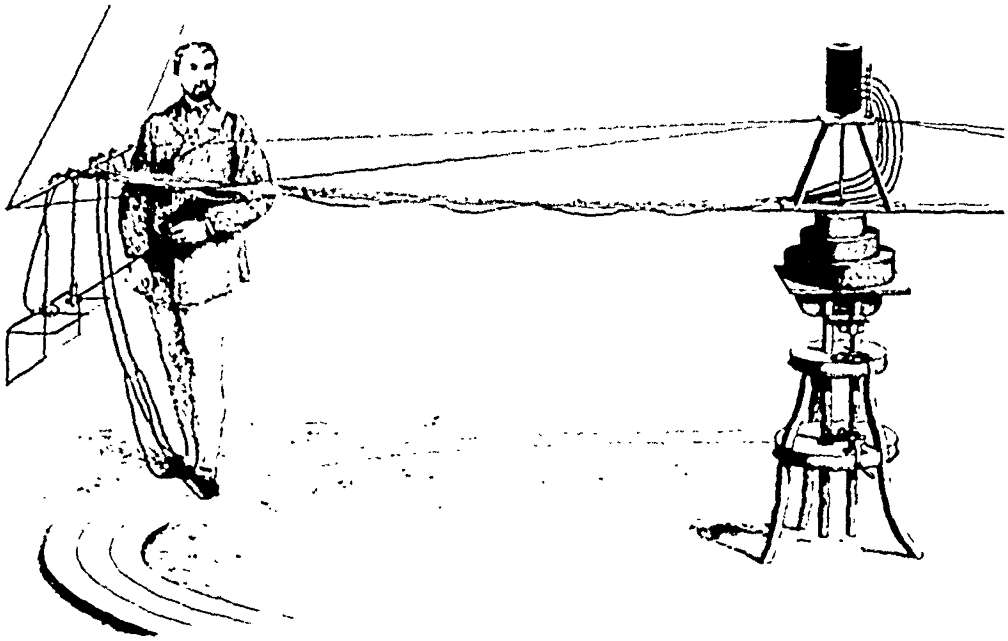

FIG. 1
Carlet's apparatus for recording gait.

The anatomical period was born with Galen [17, 18] (131–210 A.D.) and with it the first intimate knowledge of the origin, insertion, and function of muscles as related thereto. Even with this advantage the history of human locomotion reveals sterility until the inauguration of a new era by Borelli [19, 20] (1608–1679). He is credited with having given first consideration to the (1) motor force, (2) the point of body support, and (3) the resistance to be overcome. As a mathematician trained by Galileo, he introduced the mechanical viewpoint during the period when only observation was applied to the study of gait.

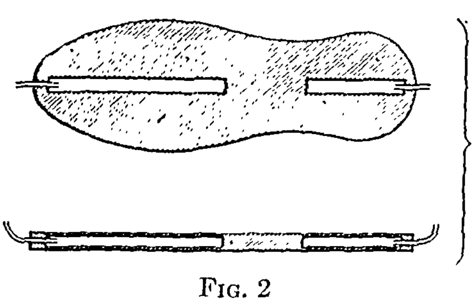

FIG. 2
Sole of Carlet's shoe showing air chambers in mid-line of heel and forefoot.

More than one hundred years later, Paul J. Berthez [21] (1734–1806), of Montpelier, clearly defined the idea that the motive force of the body rests in muscle function. In a memoir published by Chabrier [22] about 1820, the relationship of muscle function of the fixed lower extremity was shown to be inverse to the function of the free extremity. He also included the vertebral muscles in the group essential for normal locomotion.

Twenty-two hundred years elapsed, therefore, during the period when the study of this subject was controlled only by observation of human gait. The experimental period was introduced by the Weber Brothers [23], working in Leipzig, at the beginning of the nineteenth century. Their work represents a detailed study of the structures involved in locomotion while experimental data provided the basis for elaborate mathematical deductions.

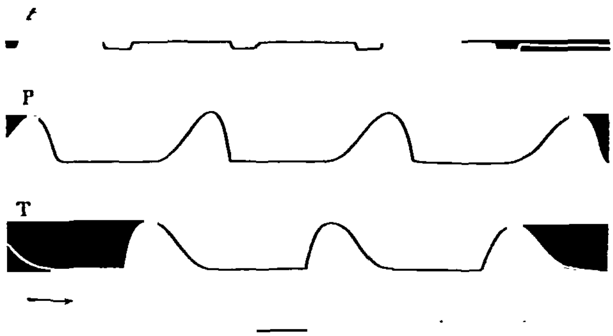

FIG. 3
Carlet's gait curve, P—heel, and T—forefoot, recorded separately.

FIG. 4
Carlet's gait curve, A—heel, and B—forefoot, recorded simultaneously.

Their paper on the physiology of motion and locomotion and the mechanism of the joints was published in 1836. This was the most important work of the period, although many of their major conclusions do not find general acceptance at the present time.

In fact their theory that the respective legs obeyed the laws of a pendulum was attacked and disproven by G. B. Amand Duchenne[24, 25] (1806–1875), a contemporary working in Paris. The relationship of muscle function to locomotion was settled with finality by demonstrating the impossibility of progression in the presence of paralysis of the flexor muscles of the thigh.

It was not until the last quarter of the nineteenth century that G. Carlet[26], a pupil of Marey's at the College of France in Paris, made the first graphic records of human gait. Shoes with India rubber soles were altered by making an air compression chamber for the heel and forefoot (Fig. 2). Rubber

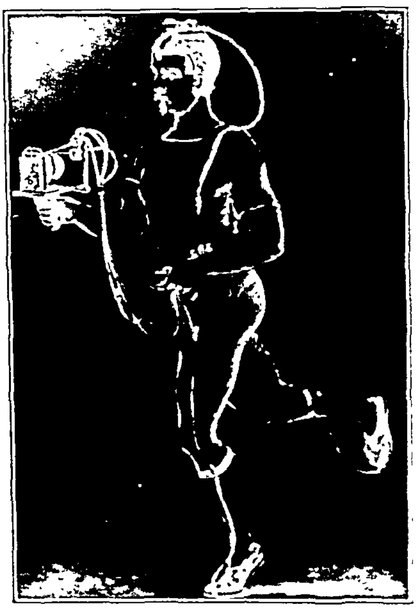

FIG. 5
Marey's recording mechanism.

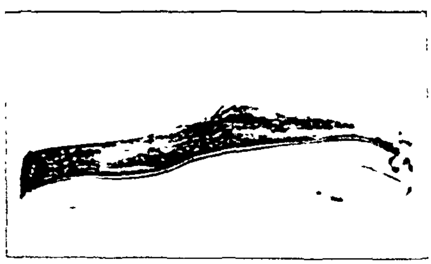

FIG. 6
Marey's shoe with one air chamber in mid-metatarsal region of sole.

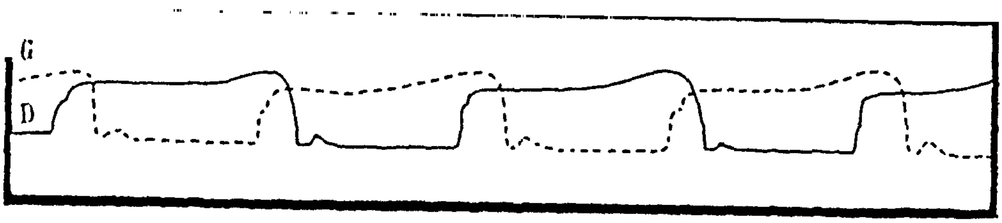

FIG. 7
Marey's gait curve, showing increasing pressure to the point where the pressure is suddenly released by lifting the foot.

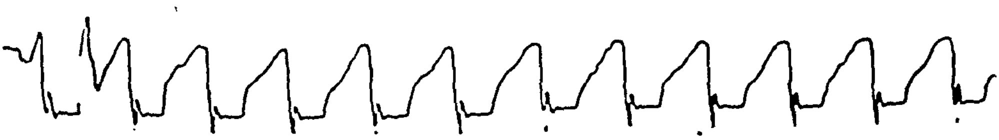

FIG. 8
Author's gait curve of an equinus limp which reveals increasing pressure on forefoot to the point where pressure is suddenly released.

tubes connected these respective chambers with a Marey tambour and a kymograph for recording by means of a smoked drum. Owing to self-evident indications, the latter was mounted on an axis in the center of a circle twenty meters in circumference (Fig. 1). He was of the opinion that the "radius of curvature was sufficiently large so as not to impede, in any way, the walk that one could consider accomplishing in a straight line". This opinion might be subject to question, along with certain other conclusions which he drew. For

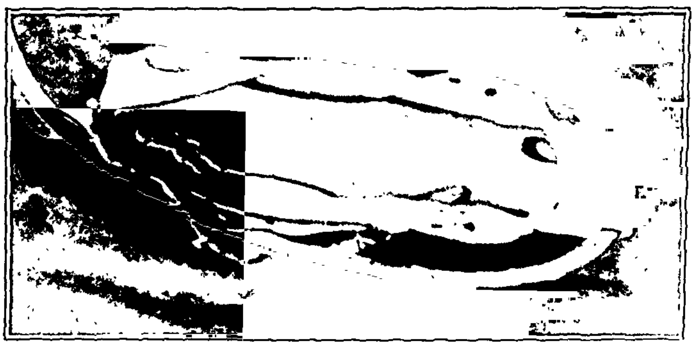

FIG. 9
Interior of shoe; air chambers of three cubic centimeters' capacity placed in relation to the tripod of the foot.

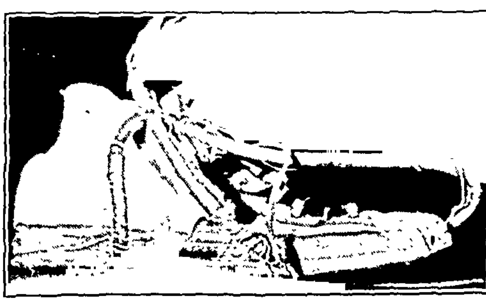

FIG. 10
Exterior of the shoe. The rubber tubes from respective air chambers converge into one by means of a three-way metal connection.

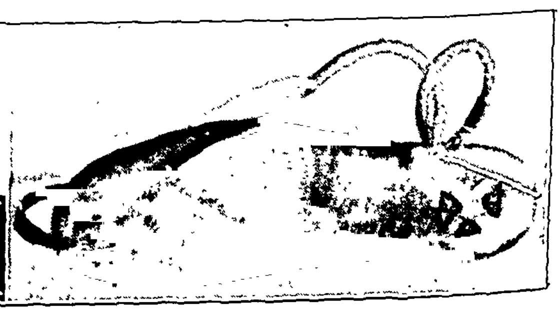

FIG. 11
Sole of shoe. Wires exposed over level of respective air chambers, at level of heel, fifth metatarsal, and first toe, respectively.

the present, it is more fitting that one should express appreciation for his ability and ingenuity, while criticism awaits its proper place. Due to the absence of relationship of the two air chambers to the three weight-bearing points of the foot, his curves of gait (Figs. 3 and 4) did not reveal the function of the tripod of the foot.

In this excellent thesis, one sees the influence of Marey [27] who published his first work on "Terrestrial Locomotion of Bipeds and Quadrupeds" in 1873. While Professor of Physiology at the College of France in Paris, his continued interest in the subject of locomotion is revealed by his bibliography which extended over a period of seventeen years. He constructed a small recording apparatus (Fig. 5) which was carried by the subject and was activated by one air chamber in the midmetatarsal region of the sole of the shoe (Fig. 6). The character of the curve (Fig. 7) produced by normal gait was therefore comparable to that of an equinus limp (Fig. 8) as recorded by our apparatus.

FIG. 12
First record made on kymograph with smoked paper.

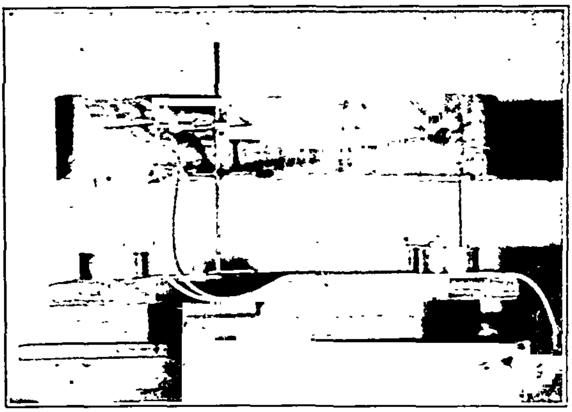

FIG. 13
Two kymographs for making seven-foot record of both right and left foot.

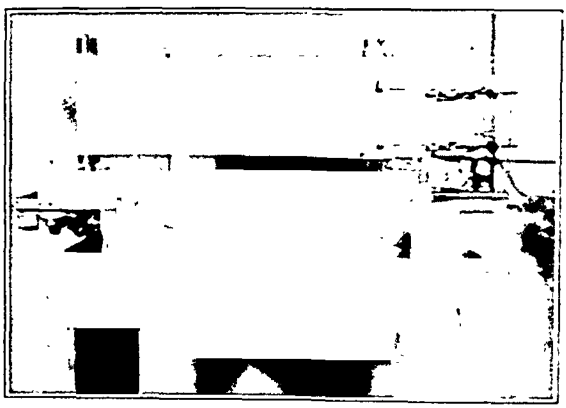

FIG. 14
Continuous recording mechanism showing electric timing mechanism—lower tambour for right foot and upper tambour for left foot.

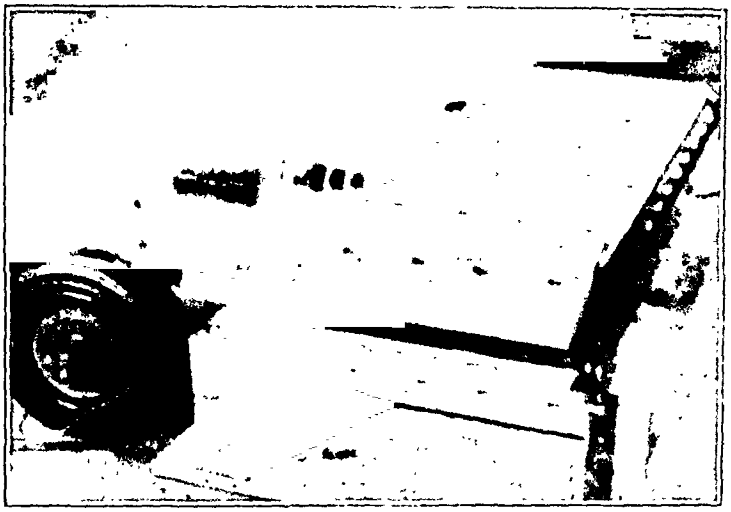

FIG. 15
Treadmill under construction. Boards bolted to two endless belts.

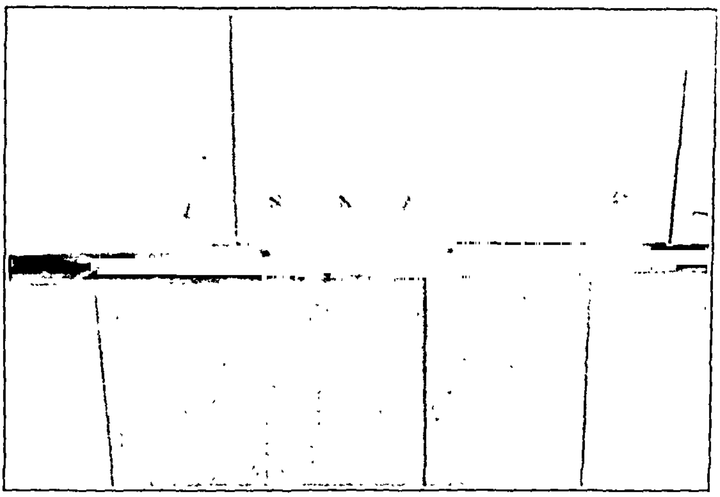

FIG. 16
Treadmill boards covered with aluminum. Brass springs fixed on platform to come in contact with aluminum on the ends of treadmill boards.

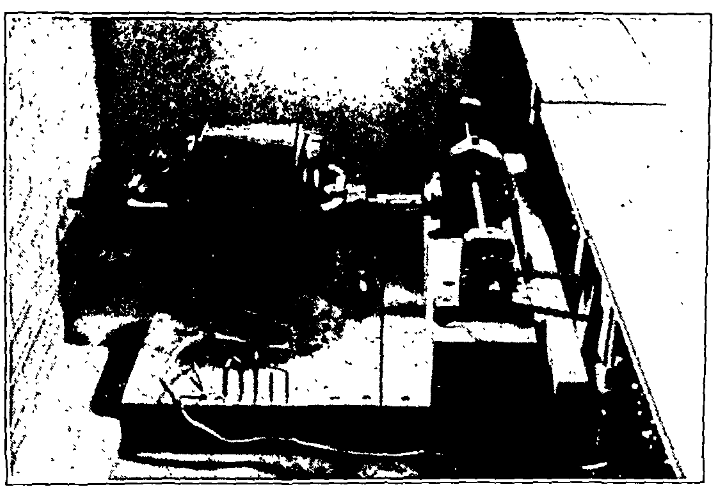

FIG. 17
One-horse-power motor, gear reducer, and chain drive.

The work of Eadweard Muybridge[28] on "Animals in Motion" was begun in California in 1872, later continued and completed at Pennsylvania University in 1885. He employed the electro-photographic method of recording the locomotion of the horse and other animals, including a short study of gait of man. The work of Pettigrew[29], Braune and Fischer[30, 31], Dercum[32], Bloch[33], Richer[34, 35], and others must be passed without description at this time.

Our work, which began in 1926, was expressed in the form of the "basograph"[36] in 1927. This was later abandoned because the principle of the pendulum was shown to be useful within limits which were too narrow to be of practical value. Efforts made in several other directions were equally unsuccessful.

In its present form, the pneumographic method of recording gait requires special shoes. The "normal" foot

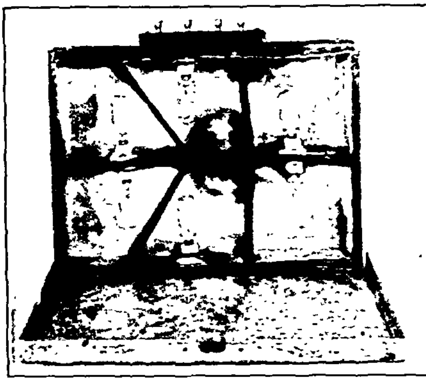

FIG. 18

Back of transillumination box, showing three respective compartments with lights for each foot.

FIG. 19

Front of transillumination box with outline of feet on ground-glass plate. Right heel and left forefoot illuminated.

presents three principal points of pressure in bearing superincumbent weight. We have, therefore, placed the air compression chambers of three cubic centimeters' capacity under the heel, fifth metatarsal head, and the first toe (Fig. 9). A rubber tube of five thirty-seconds of an inch, interior diameter, passes from each of these chambers to the lateral side of the shoe. By means of a three-way metal connection, these are made to converge into one tube of the same size (Fig. 10). This tube from the right shoe is connected with the lower tambour, while a corresponding tube from the left shoe is connected with the upper tambour. The electric timing mechanism records a vertical line on the base line at intervals of five seconds (Fig. 14).

Smoked paper on a kymograph was at first employed to reveal the possibility of getting records by this method (Fig. 12). Two kymographs were then used to provide a record seven feet in length (Fig. 13). The records were consistent from week to week, but this recording mechanism

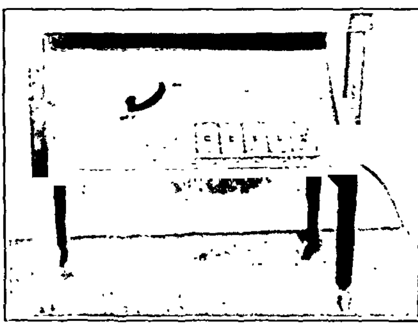

FIG. 20

Front of control board showing lever for rheostat control of one-horse-power motor and five switches for operating all of the equipment.

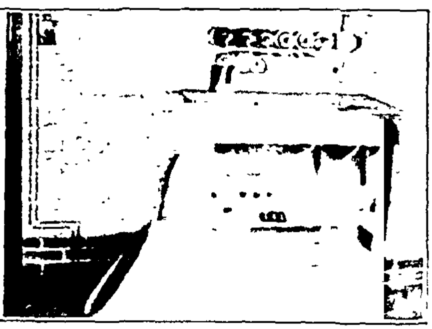

FIG. 21

Back of the control board showing rheostat, fuse block, and cable which contains the wiring.

was unsatisfactory from every point of view. A continuous recording instrument was constructed to provide ink records by using pens made from acetate film and special capillary tubes (Fig. 14).

Foreseeing the necessity of reducing the interpretation of these graphic records of gait to the medium of physical laws, it was essential to construct a treadmill. A section of the conveyor system from the Eastman Kodak Company was used as a foundation (Fig. 15). Boards were bolted on two endless belts to provide a smooth surface comparable to a floor. The surfaces of these boards were covered with aluminum which was made to overlap the ends on the left side. A six-foot strip of brass, one-eighth of an inch thick and one inch wide, was fixed to the left side of the platform surrounding the treadmill. Brass springs, one inch wide and four inches long, were

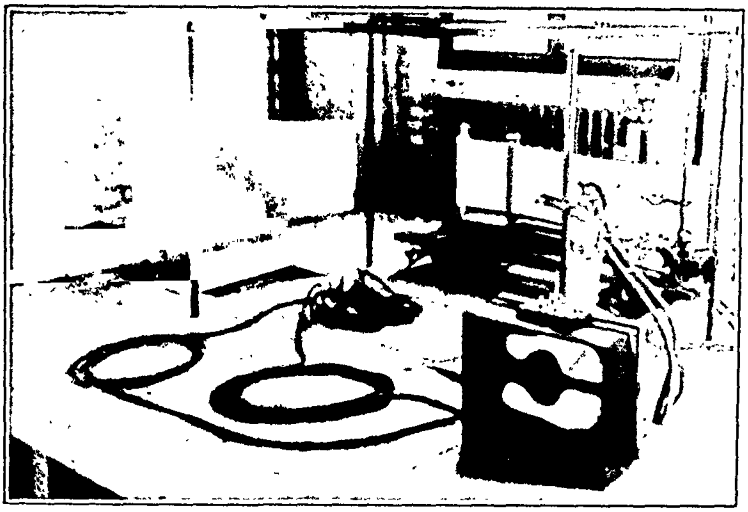

Fig. 22

Arrangement of apparatus, motor, shoes on treadmill, transillumination box, 1300-watt, tungsten, water-cooled lamp, and continuous recording mechanism.

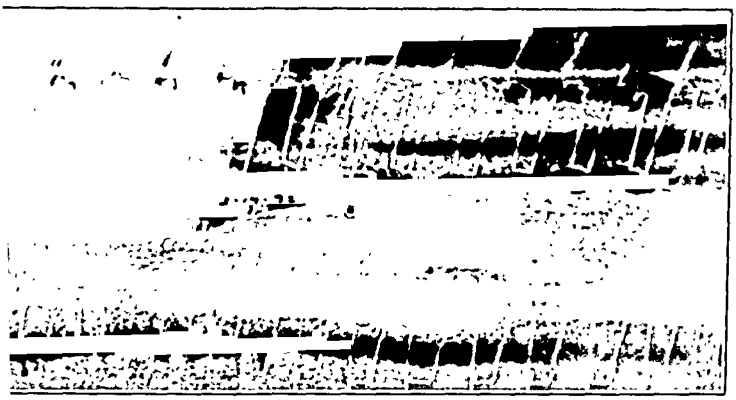

Fig. 23

Gait curves made when subject walked on a concrete floor. Jpper curve: left, "normal". Lower curve: right, equinus.

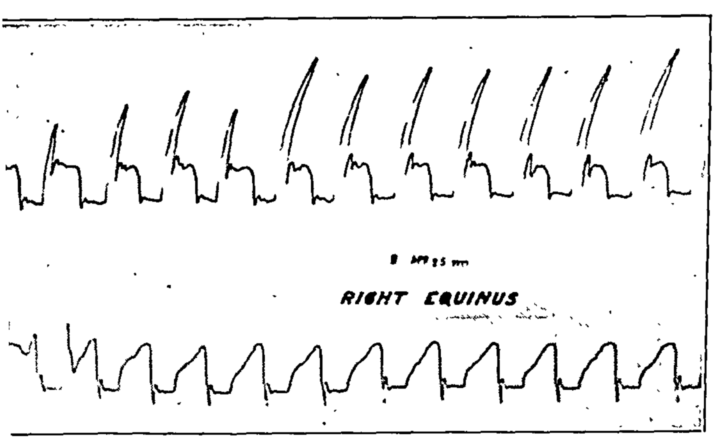

Fig. 24

Gait curves made when same subject walked on the tread-ill. Upper curve: left "normal". Lower curve: right, uinus.

made to touch the overlapping edges of the aluminum (Fig. 16).

These springs formed one side of an electrical circuit. The other side was formed by wires in the soles of the respective shoes. These wires were exposed over the levels of the respective air chambers at the heel, fifth metatarsal, and great toe (Fig. 11). Each of these respective wires was led to a light in the corresponding compartment of a transillumination box (Fig. 18) which had the soles of the feet outlined on a plate of ground glass (Fig. 19).

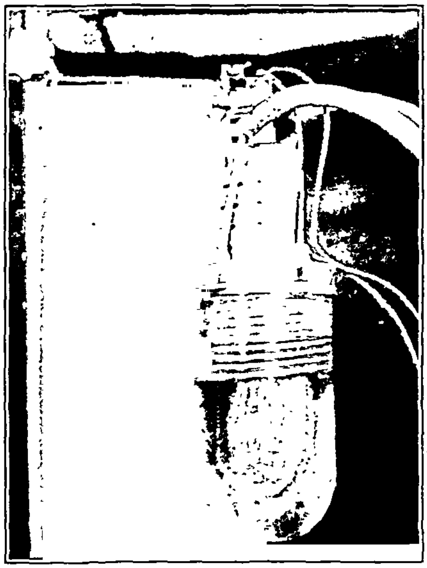

Fig. 25
Thirteen-hundred-watt, water-cooled, tungsten filament lamp.

The treadmill is driven by a one-horse-power, direct-current motor through a gear reducer (135 to 1) with chain drive on sprockets with a ratio of 20 to 36 (Fig. 17). This gives the treadmill a maximum rate of travel of four miles per hour. Slower rates of speed are possible through the use of the rheostat on the control board (Fig. 20).

This control board (Figs. 20 and 21) also carries five switches which operate the spot lights, the transillumination box, the water-cooled, thirteen-hundred-watt, tungsten lamp (Fig. 25) and the continuous recording mechanism, all of which are shown in Figure 22.

The records produced have been made on both a fixed surface—such as a concrete floor—and on the treadmill. These records are very similar in their characteristics. In support of these and other statements made pertaining to the pneumographic method of recording human gait, the evidence was based on records sufficient to form one continuous strip, one hundred and twenty feet in length. They were made on various dates between January 6 and May 5, 1932 inclusive. The present indications are, therefore, that the treadmill may be used, at least in some instances, without essentially altering the gait curves (Figs. 23 and 24).

The analysis of these records has been made possible through the use of moving pictures. A sixteen-millimeter camera is focused on the subject, the treadmill, the recording mechanism, and the transillumination box as revealed in Figure 22. While the subject walks on the treadmill at the rate of four miles an hour, the curves are being continuously recorded and the transillumination box reveals the respective points of pressure; pictures have been made at the rate of sixteen, thirty-two, and sixty-four exposures per second. Subsequent projection provides for study, interpretation, and analysis in slow motion.

Four hundred feet of moving pictures showing all of this apparatus,

together with the method of recording "normal" gait and imitated limps, have been made.

CONCLUSION

Our problem is the analysis of gait. The method of approach is as follows:

1. The development of the physical mechanism essential for making graphic records of normal and abnormal gait. In this paper we have presented evidence which suggests that the pneumographic method may serve this purpose.

2. The classification and analysis of "normal" curves on a basis of given age, weight, and height of subjects is the next phase of our work.

3. The analysis of gait curves which result from abnormalities of known etiology in individuals of the same age, weight, and height group must then follow.

4. Our goal is the determination of the influence of treatment of known pathology as revealed by graphic records of individual gait.

The Advantages to be Gained by This Research Program

Through the development of a method for recording gait and the subsequent analysis of the curves produced, abnormalities in function of the lower extremities may be brought under the influence and control of comprehensible physical laws. Progress, under treatment, should then be determined by the same method of measurement.

Facts, instead of opinions, therefore, may in the future be used to define the prevailing limitations in function. Only through the use of analyzed curves, indicating the presence or absence of improvement, may the repeated mistakes of empiricism be eliminated from the treatment of deformities. The correction of deforming limps constitutes a large part of orthopaedic surgery. From year to year, this work has continued to be directed by opinion. This branch of surgery may be brought under the influence of physical laws only by continued encouragement of systematic efforts.

NOTE.—In the paper as read, the following acknowledgment appeared as the Introduction.—EDITOR.

It is essential that you should be apprized of those to whom I am indebted for the privilege of presenting this work on gait. Dr. George H. Whipple, Dr. John J. Morton, and Dr. Wallace O. Fenn have made it possible. Over a period of several years, advice and assistance have been sought from many sources. Dr. Fenn, Dr. Stafford L. Warren, Mr. Francis W. Bishop, and Dr. John R. Murlin's Department of Vital Economics have all been most helpful. Dr. Milton Chapman, Dr. William A. Sawyer, Mr. Gustave F. Aldinger, Mr. Harris Tuttle, and Mr. Fordham Tuttle of the Eastman Kodak Company have given valuable assistance and cooperation. Mr. E. H. Branson and Mr. Walter H. Hoppe of the General Railway Signal Company were also generous with time and assistance. Mr. F. W. James of the Bausch and Lomb Optical Company located the motor and gear reducer for the continuous recording mechanism, and the one-horse-power motor which now drives the treadmill. Without his immediate help at the time, this work would have been materially delayed. To Mr. Jack Schabert, of the Taylor Instrument Company, must be given credit for having provided the capillary tubing upon

which we were dependent for successfully recording with ink. The success of this method of recording is shared with the Telautograph Company of New York. From there we received the particular ink essential for our purpose. Directly and indirectly we are indebted to Mr. Harry Gordon of the Rochester Telephone Company, for parts made useful from old switch boards which had been given to Dr. Warren. Mr. Edward A. Knight, Mr. Charles Alberts, Mr. W. H. Woodworth, and Mr. C. Beach have willingly and freely placed their respective shops at our disposal. An expression of appreciation must be made for the loan of a thirteen-hundred-watt, tungsten, water-cooled lamp by the General Electric Company, through the kindness of Mr. John G. T. Gilmour.

To utilize the fullest advantage of this combination of resources and successfully build the present equipment essential for the study of gait, required the interest of a person of ability who was willing to work. Mr. Arthur L. Heath is responsible for the construction of the present experimental apparatus. He has, for the past three months, been ably assisted by Mr. Charles Brown. With all of this cooperation, I appear before you as the spokesman for my colleagues.

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THE RÔLE OF SYNOVECTOMY IN CHRONIC INFECTIOUS (PROLIFERATIVE) ARTHRITIS

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Until the time shall arrive when, given a patient with the early symptoms of arthritis, the course of that case may be confidently predicted and crippling deformities and disabilities forestalled by treatment, there will always be individuals for whom Nature's efforts must needs be assisted by surgery. If experience and observation teach us anything, it is that the local manifestations of toxic invasion of a joint are indicative of the same cellular responses that one expects to find in any tissue subjected to the inroads of bacteria and their toxins, modified chiefly by the nature of the tissues involved. Furthermore, it is common knowledge that infections vary in virulence, and individuals are possessed of different degrees of resistance to bacterial infection. This is quite as true of those infections giving rise to arthritic changes as of any other infective lesions. It is a fairly well established conclusion that there is machinery in the human body that is thrown into action just so soon as systemic bacterial invasion takes place, which elaborates biochemical substances tending to render the invading toxins inoccuous. In addition to this systemic reaction there will be local defensive measures taken which are designed to prevent extension of infected areas by enveloping them within a cordon of connective tissue. The more chronic the infection, the more probable is it that synovial erosions will not be the dominant feature of the damage inflicted upon the interior of the joint. Proliferation of the normal synovial villi, if unaccompanied by loss of their synovial coverings, does not hold the possibility of so much disablement of the affected joints as is the case in more acute infections where denudation of synovia and toxic erosion of cartilage pave the way to deformity and loss of motion. Proliferative changes in the villi at the line where the synovia is reflected from the cartilaginous margins cause them to creep in over the articular cartilage in the form of a pannus which sends down loops of newly formed blood vessels to penetrate the articular surface and attach themselves, as do the "runners" of certain plants that propagate in that manner, sinking their rootlets into the soil, remotely from the mother plant. In all chronic infections of joints, villous changes are an early and a common, probably a constant, sign. Invasion of the joint is through the arterial stems supplying the individual villi and it is through stomata in the walls of these vessels that organisms or their toxins escape, setting up, at once, a round-celled infiltration. Simultaneously there is inaugurated in the connective tissues a reparative reaction. In the course of time, and in patients whose resistance is good, the villous hypertrophy subsides by the metaplasic route. I have had occasion to observe the nature of this change in a number of operative cases. Apparently the villi undergo a fatty degener-

ation, beginning at the tip and extending back to the base. I have seen individual villi with single, large, opalescent fat droplets on the tips of the stalks and I have observed in advanced cases these individual droplets coalesce into a pannus of solid, homogeneous fat, unencapsulated, and easy to strip off the synovial wall, leaving a smooth, soft surface and a synovial membrane apparently normal in all respects except perhaps a trifle thickened. The pathology of all types of the proliferative (toxic) variety of arthritis, so far as the joints are concerned, lies in the villous folds of the synovial membrane, at least in the beginning, and the type of villus to be met is more dependent upon the chronicity of the underlying infection than upon the particular bacteriological strain causing it. The acute gonorrhoeal invasions of joints develop their joint pathology so rapidly that villous proliferations have no time to form and one finds a thick, oedematous synovial membrane. The layers of lining cells of this synovial membrane have been rapidly denuded and the deeper-seated connective tissues quickly multiply so that many and firm adhesions are formed within a short time after the joint becomes involved. Almost no villous hypertrophy will be observed in these acute cases.

Another common type of infection occurs without bacterial specificity and is characterized by very numerous, dark, purplish-red villi. They are short and stubby with their synovial coverings intact. Some excess of fluid may be found in the joint and perhaps a few fibrinous clots floating about or adherent to the villi. When the capsule is incised in performing an arthrotomy, the edges of the wound evert and these villi are turned out into the wound in such numbers that the interior of the joint cannot be inspected until the incision has been greatly extended and its edges retracted. This type is subacute in its intensity as compared to the fulminating gonorrhoeal variety to which reference has just been made. These patients may show multiple joint involvements and there has always been evidence of inflammatory reactions in the joints and often constitutionally as well. A second and more chronic variety of villous hypertrophy, accompanied by less acute clinical signs, shows more massive villi, often branched, in which the synovia is intact. It is in this type that the majority of the fatty degenerative changes have been observed.

Apart from damage inflicted upon the joint by the possible invasion of the articular cartilage by the pannus and its consequent impairment of function, there is a tendency to distend the capsule, rendering the joint unstable and less capable of normal and comfortable action. In such cases it is desirable to explore such articulations with a view to removing any products of previous inflammations and such villous remains as threaten to erode cartilage and provoke a situation that will increase liability to ankylosis and deformity. Synovectomy offers the best opportunity for preventing certain of these disabilities in carefully selected cases, and, if arthrotomy for this purpose is decided upon, it should be through the median-patellar incision which gives by far the best opportunity to inspect the joint and remove whatever requires removal. Con-

valescence from this procedure is not longer than from other approaches—often not so long—as early active measures to restore flexion are not contra-indicated.

A brief summary of the following four cases will indicate what is reasonable to expect in patients of the types described.

CASE 1. Miss E. H., twenty-three years old, single, is an intelligent girl, a secretary by occupation. There was nothing of significance in her history prior to the onset of her present symptoms which were first related to me in November, 1930. When she was seventeen years of age she had an acute attack of pain and swelling in her left elbow. She was treated for acute articular rheumatism and the symptoms subsided in a few weeks. only to be followed by similar signs in the right wrist and certain of the phalangeal joints of the right hand. The trouble here was not so acute or disabling as had been the case with the elbow, but symptoms persisted in both localities for two years before the right knee began to swell. The knee has continued to trouble her, gradually becoming more painful and recently beginning to flex. About fourteen months after the right knee started to swell, the left knee began to behave in the same manner and when I first saw her she was so disabled that she was brought to my office with great difficulty, requiring the assistance of two persons to carry her. She could not get out of a chair alone and could only walk with a person on either side, supporting most of her weight, and at that very slowly and painfully. She was twenty pounds under her normal weight. She was anaemic (hemoglobin sixty per cent.) and was suffering a great deal of pain on motion of the affected joints. The left elbow was flexed thirty-five to forty degrees, was much swollen, the surface temperature was increased, and there was a coarse crepitus to be felt when the joint was flexed the few degrees in which this motion was possible. The swelling was capsular. The right wrist had little motion, was swollen and warm to touch, as were also two of the second phalangeal joints on the right hand. Both knees were much enlarged, particularly the left; both were permanently flexed about twenty to twenty-five degrees. There was marked capsular thickening, increase in surface temperature, and motion in flexion to slightly beyond a right angle was painful and guarded by spasm. During the summer preceding the November in which I saw her, she had been treated in casts at a Boston hospital for five weeks and during the rest of the time she had been having sun baths. Fearing an extension of a pannus of synovial villi over to the articular cartilage, some suggestion of which was evident in an x-ray which was taken at that time, an arthrotomy of the right knee was advised and performed the latter part of November, 1930. The joint was opened through a long lateral (internal) incision. The capsule was found much thickened and, as soon as it was incised, there was an escape of a slight amount of clear synovial fluid, without flocculi, and an immediate extrusion of small, dark-purplish villi which were encroaching upon the articular cartilage. There were no demonstrable adhesions and no actual erosion of cartilage. These villi were quite freely removed by scissors dissection from the quadriceps pouch and from the space on the inner side of the joint where the synovial membrane was reflected back from the cartilage, as well as at the origin of the alar ligaments. The joint was washed out with a considerable quantity of hot saline and the capsule and skin closed without drainage. No cast nor any fixative splint was applied. She recovered well from the operation and by the autumn of 1931 had improved to such an extent that she could flex the operated leg to well beyond a right angle, and could practically fully extend it. The swelling never recurred in the knee and it was relatively painless. The left knee showed no change. The elbow had improved, though nothing had been done for it locally except to keep it bandaged with an ace bandage and to prohibit its use. In September, 1931, she had a dozen intravenous injections of oxybenzoate by her family physician, in the hope that her other joints would be benefited. During the fall and early winter she was able to get about more, the swellings disappeared, her general condition improved, and, in February, 1932, she came to the office alone, walking without pain or limp and showing no capsular

thickening in either of her knee joints, a nearly normal range of motion, and an elbow that could be almost fully extended, was painless, and manifested no acute symptoms. The phalangeal joints were slightly more prominent than their fellows and the wrist was still somewhat restricted in motion but caused her no trouble. Her anaemia had disappeared and her weight was only a couple of pounds under what had been her best weight. She was ready to resume her secretarial work. The following is a report from the pathologist to whom the material removed from the knee joint was submitted:

"Specimen consists of three pieces of tissue the largest of which measures two centimeters in length and one centimeter in width and eight millimeters in thickness. The other pieces of tissue are somewhat smaller. On section the tissue is pinkish red in color and firm in consistency. The pannus submitted has essentially the same appearance as the other pieces of tissue. Due to its size it is fixed without further sectioning. Sections microscopically through the tissue submitted show it to be composed for the most part of fibrous tissue containing a few blood vessels, showing marked round-cell infiltration characteristic of a chronic inflammatory process. The pannus seen grossly contains numerous blood vessels and also shows moderate round-cell infiltration. There is no evidence of malignancy or tuberculosis in the tissue submitted."

Case 2. Mrs. S., forty-four years old, was first seen October 22, 1930. Patient had had no trouble with her joints until eight years before, when her last baby was born. Three weeks after that she had pneumonia and was in bed five months. When she was a school girl, for six or eight winters, she used to have bad attacks of tonsillitis. As a young woman of twenty she had acute articular rheumatism, but made a complete recovery. She had her tonsils out and her teeth were negative to x-ray. After the pneumonia she was all right for a year, when her right wrist and the second joint of the right middle finger began to swell and pain her, and a little later the right and then the left knee became involved. These were painful, red, and tender, as well as swollen. After that the joints slowly but steadily grew worse and a year before the patient came for examination these joints had begun to contract, and this tendency had increased. She was getting about the house with a good deal of difficulty, but still doing most of her work. If she was not on her feet she suffered no discomfort and there was no increase in the swelling. No new joints had been attacked. The wrist was not swollen when examined and there was no pain nor restriction of motion. The middle finger was still enlarged at the second joint. Both knees were swollen capsularly with some excess of fluid but no heat. Motion was possible to full extension and nearly full flexion. X-rays taken one year before were said to have been negative. Hips were normal in motion, though she said that in sitting she had some discomfort in them. General health was excellent. The diagnosis was an apparently quiescent villous arthritis of both knees with little active arthritis. Synovectomy was advised. At the time of the operation, which was performed in October, 1930, the two knees presented much the same condition. The right one was operated upon two weeks before the left; in each a lateral incision was made over the inner aspect of the joint. The quadriceps pouch was freely incised from above down, the incision being carried well below the line of the joint. There was a moderate excess of fluid in both knees with a good many flocculi floating in the fluid and a few adherent to the villi. The villi were quite good size, were dark-purplish in color, and a few were arborescent with an occasional suggestion of beginning fatty degeneration at their tips. There were no firm adhesions anywhere. In the quadriceps pouch, finger dissection met with some opposition which was easily overcome. For a half inch in from the reflection of the synovia on the inner condyle the cartilages were covered by a pinkish-colored, non-villous pannus which, when stripped off, showed a roughened, striated cartilage beneath. A large quantity of hypertrophied villous material was removed by scissors dissection. The joint was thoroughly washed with hot saline and the capsule, which was fully three-eighths of an inch thick, was closed with interrupted chromic catgut sutures. The skin was closed without drainage. Passive motion was begun on the knee first operated upon at the end of a week, but this was interrupted for a week after the second knee was done. The woman was in the hospital one month and began to get about on crutches in five weeks. She was last seen in November, 1931, when she was getting about very comfortably, unsup-

ported, could go over the stairs—which she had not been able to do for nearly a year before she was operated upon—had normal flexion in both knees, but could not extend the right quite as fully as the left, and there was no excess of fluid in either joint. There did not appear to be any capsular thickening. She reports that she is steadily increasing the range of her painless activities. Pathological examination was essentially the same as reported in Case 1.

CASE 3. Mr. T. M., forty-four years old, is a cook. He has to be on his feet for nine hours a day for the greater part of the time. He has a congenital dislocation of the right hip which does not trouble him much. About ten years before, without any known cause, he had begun to have swelling in the left knee and shortly after in the right, and ever since he had had alternate aggravation and recession of the swelling in both knees, on a four-day "cycle". When the left was at its maximum, the right was at its minimum. When the swelling was down, there was not much discomfort or disability. When at its height it was very uncomfortable and disabling. There were no other symptoms, local or constitutional. Physical examination showed a well developed and nourished man with congenital dislocation of the right hip. He walked with limp, using two canes. Left knee was quite swollen, right one less so, apparently not due to hydrops wholly, but probably caused chiefly by villous thickening,—a typical case of intermittent hydrops. Heat was the only agent that offered him any relief. He was given Fowler's solution and quinin for a month. Synovectomy was then to be tried if he was not relieved. On March 4, 1931, the right knee was operated upon, when the swelling was in the recessive stage. The joint was full of small purplish villi among which in places there was considerable fibrinous clot, adherent to villi and free, with no great excess of synovial fluid. A lateral, external incision was used. The villi were freely dissected with scissors. Some pannus formation was found over the internal condyle. There was a considerable accumulation of fluid in the joint following the operation, which subsided in two weeks. Since then there has been no indication of the former periodic swelling. The knee is still somewhat thickened on either side of the femoral condyles but the quadriceps pouch is free from swelling. He is able to walk much more comfortably and to do his work with far less difficulty. The periodicity in the swelling of the left knee has also ceased, but the joint is about two inches larger than the operated knee. The patient is awaiting a favorable opportunity to have that joint treated in the same way. Motions in the right knee are practically normal.

CASE 4. Mr. L., fifty-three years of age, is a merchant who had been suffering for over six years with pain, swelling, and disability steadily increasing in several joints. The first to become involved were the right elbow, both wrists, two or three of the metacarpophalangeal joints of the right hand, and, about two and a half years later, the right hip and right knee. He had had various sorts of treatment for the smaller joints, mostly medical and dietetic in character. They progressed with varying success and at the time he was first seen by the author, on account of the trouble with his knee and his hip, these earlier affected joints were fairly quiescent, with some loss of motion in the wrist and about fifteen degrees of permanent flexion at the right elbow with a little swelling on either side of the olecranon process. The metacarpophalangeal joints appeared to be somewhat enlarged, chiefly due to the interosseous atrophy. His general condition seemed to be very good. His tonsils were not enlarged or reddened, the teeth were in good condition, but he was having some intestinal disturbances in the form of gas and a certain amount of discomfort after eating, referred to the epigastrium. He was hospitalized for a short time to see if it were possible to discover any focal infection. Unless it were gastro-intestinal, there did not appear to be any such focus. There was a slight amount of secondary anaemia. Local bandaging to hip and knee, high oil enemata, and general hygienic treatment were followed out for a year with but little betterment. There were no acute signs in the knee. X-rays were negative. Fear of the inroads of a villous pannus led me to urge a synovectomy which was performed in 1931. In this case a median patellar incision was employed, which gave an excellent view of the joint. The capsule was not very greatly thickened. The quadriceps pouch was occupied by a

yellowish, homogeneous mass of fat, unencapsulated, which could be easily dissected away from the basement membrane, leaving a smooth surface, a trifle thicker than the normal synovia, without rugae, and of a normal color. Over either condyle and at the reflection of the synovial membrane there were still some villous enlargements, many of which were showing terminal fat drops. Convalescence was uneventful; passive motion was started in a month, and walking with weight-bearing was permitted at the same time. Full motion in flexion and extension was allowed in seven weeks and walking with full weight-bearing soon followed. All swelling had subsided and walking, so far as the knee was concerned, was a comfortable proceeding. Because the right hip still caused a little disablement in locomotion, and the wrists and elbows (though nearly symptomless except for such restriction in motion as the arthritis had already caused) still appeared to harbor a little activity of the infection, it was thought advisable to give the man a course of intravenous oxybenzoate injections. This was accordingly undertaken by Dr. Albert G. Young with a very satisfactory outcome.

These four cases differ considerably in type, more perhaps in the observation of the individuals than one would glean from merely reading the above descriptions. The girl described in Case 1 was a sick person. She had quite a severe infection or was lacking in resistive power. Constitutionally she manifested fully as much reaction to the invasion, whatever it may have been, as she did locally in the joints. Case 2 was that of a woman whose constitutional reaction was slight. She had had acute articular rheumatism and she had been very sick with pneumonia, following which a polyarthritis developed which gave rise to rather acute symptoms in certain of the articulations. Gradually these features subsided, leaving her seriously handicapped in her ability to get about, but unaffected in respect to general health and with no progressive tendencies in other joints. Case 3 was that of a man who for several years had suffered from intermittent hydrops in both knees. No other joints had ever been affected; no focal infections were determinable. Apparently a rhythmic lack of vasomotor control over the circulation in the villi of his knees was the cause of his symptoms. He was the picture of health in all respects and able to do his work—which involved constant standing—under a good deal of handicap but without great discomfort except for the short interval when each knee was at its maximum of distention. The man described as Case 4 possibly had a gastro-intestinal origin for his low-grade polyarthritis, which was tending to subside because of his high resistance to the infection and the excellent general care he had taken of himself. One joint only was causing him much inconvenience and in this the villous hypertrophy had undergone a complete metaplasic transformation to fat.

In all these cases, except possibly the first, the value of synovectomy to the patient was the removal of that which had accumulated within the articulations as a result of cellular reaction to toxic invasion and, though at the time inoccuous, was putting the joints at a mechanical disadvantage, too long a continuance of which might have resulted in permanent disability. That I conceive to be the *raison d'être* of synovectomy and only such cases as present that condition and probable outcome should be subjected to it.

FRACTURE OF THE FEMUR IN CHILDREN*

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Fracture of the femur, in either a child or an adult, is decidedly a major problem. The treatment of such a condition requires considerably more than the ordinary amount of skill. To treat it lightly or carelessly means a poor result, and a poor result means that a handicapped individual has been created. When we stop to think that the entire future of the individual depends upon the care, the skill, and the thought that we give to such a patient, it should give us pause for considerable reflection before we decide upon any one course of treatment; and if there are any misgivings as to just what should be done, skilled consultation should be sought. Many a crippled individual walks the streets today merely because his fractured femur was considered too lightly. Also, there are probably many more disabled individuals walking the streets because, in our anxiety to get a beautiful radiographic result, we have resorted to open operation.

There are cases that may require open reduction. They are very few indeed. We feel that we are consistent in saying that at least ninety per cent. of the cases operated upon would have been infinitely better if operation had been avoided.

Just what should be the aim in the treatment of a fracture of the femur? There can be but one answer,—the restoration of normal function. Normal function *should not be estimated by the radiographic appearance.* Just what are the requisites for the restoration of normal function? There are three: (1) union; (2) normal alignment; (3) normal length. There are no other requisites. The surgeon who thinks in terms of radiographic appearance will, perhaps, wonder why we have not included normal apposition. Normal apposition, while it is desirable, has very little bearing on the result so far as function is concerned. It has been demonstrated in literally thousands of cases that union will occur, certainly in children, even though the apposition is very slight. In fact, it will occur almost certainly, even if there is apparently little or no end-to-end apposition. Several inches of overlapping generally does not prevent union, though naturally such a condition should not be tolerated, owing to its marked disturbance of function. Normal function should be our aim, first, last, and always, in the treatment of any fracture.

Open operation generally may be productive of normal apposition and normal alignment. This being true, what are the objections to open operation? First, union is invariably delayed. This statement has been proven so many times that argument along that line should not be neces-

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sary at this time. Delayed union means longer fixation, longer period of hospitalization, delay in the restoration of the movements of the knee and greater atrophy of muscles. Second, the danger of infection. Infection generally means osteomyelitis, resulting in permanent fibrosis of muscle, and, in the end, a knee with marked limitation of movement. Also, shortening is very likely to occur, producing an unavoidable interference with the normal function,—in other words, a permanent crippling condition.

We realize full well that there are many surgeons who can operate on a femur, place the fragments in normal apposition, and obtain a perfectly functioning knee. We realize just as fully that there are many surgeons who cannot. The latter group comprise the surgeons who operate only occasionally, who probably would not be called upon to operate upon more than two or three cases a year. If one case in twenty-five becomes infected (this probably is a low average), then it would seem to us that the operation becomes prohibitive. If our percentage of infections in any line of clean surgery exceeds two per cent., we certainly have no right to risk the opening of a fractured femur, except under the most unusual circumstances. Mechanically, the procedure is ideal. Practically, it is one of the most dangerous procedures in the whole domain of surgery, dangerous to the future welfare of the patient. The future welfare of the patient is paramount to the conscientious surgeon.

Fractures of the upper third, non-intertrochanteric, may require open operation. If so, the operation should be done under conditions as ideal as humanly possible. Under no other conditions should the operation be attempted. As upper-third fractures may require open operation, we are not making any attempt to discuss this fracture at this time. We are concerning ourselves almost entirely with fractures of the lower and middle thirds.

About two years ago, in the Children's Orthopaedic Hospital, we began using the so called Russell's balanced traction. Our results have been so uniformly good that the procedure is now a routine. Of approximately forty cases treated, one hundred per cent. have perfect functional results. We realize that no treatment is going to give one hundred per cent. of perfect results; but any treatment of fracture of the femur which can give such a percentage of perfect functional results in forty cases is worthy of earnest consideration. Not one patient has had the slightest impairment of function. The average period of disability in these cases is about nine weeks—that is, at the end of that period, the patient is walking normally.

In many of the cases treated at the Children's Orthopaedic Hospital, we were not able to secure perfect apposition. In some of the cases the apposition was not more than a half or a third of the bony diameter; but in all cases we readily secured full length and perfect alignment—two absolutely essential requisites. We have ceased to have any concern whatever over the question of perfect apposition.

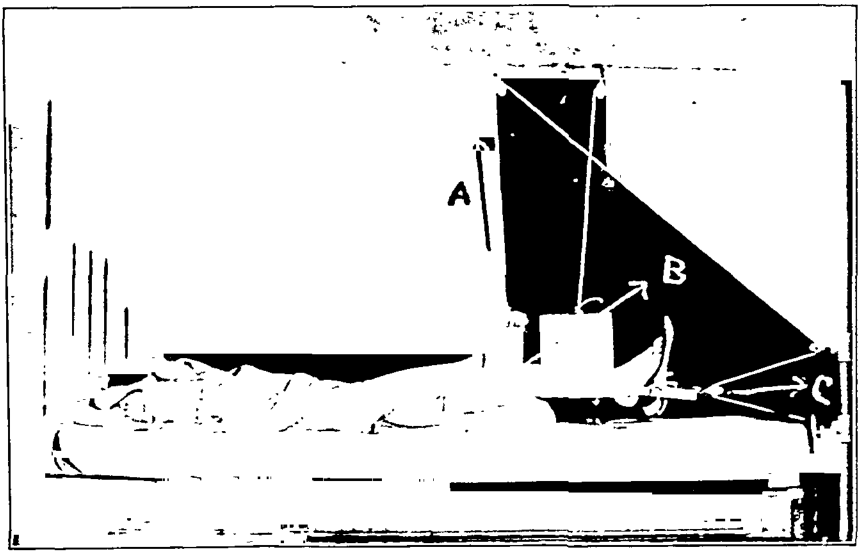

FIG. 1

Note the slight flexion of the hip and knee. The component of traction A plus traction C is traction B in the long axis of the shaft of the femur.

There have been several descriptions of the Russell balanced traction, but it may serve a useful purpose to give again a brief description.

The child is placed either on a firm bed or a frame, the frame being entirely unnecessary; the frame may facilitate the handling of the patient, but it is not essential. Hospitalization is desirable, but is by no means a necessity. Under intelligent supervision, the treatment can be carried out quite well in the home. The hip is placed in a position of about twenty-five or thirty degrees of flexion, and the knee in about the same angle. Abduction or adduction may be secured as desired, merely by shifting the frame to which the pulleys and ropes are attached. English moleskin is used for traction, but the ordinary zinc-oxid adhesive may be used. The moleskin adhesive is much less irritating. The adhesive strips are carried from the malleoli to a point just *below* the knee. It is quite important that the adhesive should not extend above the knee. The two adhesive strips are fastened to a foot piece by means of buckles. In the bottom of the foot piece a pulley is secured. A sling approximately five inches wide is placed under the knee; the upper margins of the sling are tunneled for the two tongue blades, the blades preventing wrinkling. From the center of the upper margins of the sling and going around the tongue blades, a rope is passed over a pulley attached to the frame that goes over the bed, as shown in the illustration. This rope should go almost directly upward from the tibial tubercle. The rope is continued over the pulley in the top of the frame, is carried downward to the upright of the frame at a point almost opposite the foot, where it passes through another pulley, thence over the pulley in the foot piece, and back to

another pulley also fastened to the upright. The weight is then attached. Usually five pounds are sufficient, but occasionally seven or ten may be necessary. The thigh is supported on a pillow, and the leg may be supported either on a pillow or by means of a sling. It is well to slightly elevate the foot of the bed. The patient is now in the position of balanced traction, the thigh and knee being in a position of physiological rest. The component of the pull on the legs and the vertical pull at the knee is in a line that bisects the two pulls, which is practically in the long axis of the shaft of the femur. The traction comes directly at the knee joint, and therefore is almost the same as skeletal traction. It may exert not quite as much of a pull as skeletal traction, but practical experience has repeatedly demonstrated that, with from five to ten pounds weight, the lower fragment can be pulled down within from two to forty-eight hours to a point where there may be an actual lengthening. The traction is maintained from three to four weeks. If for economic reasons it becomes necessary to send the child home from the hospital, a plaster support may be applied at the end of three weeks. If possible, a plaster support should be dispensed with. The wearing of a plaster support delays the complete return to normal function, the delay being practically the only objection.

The procedure herein outlined is not superior to the use of piano-wire traction after the method of Kirschner. Practically, however, it is fully as efficient because of the complete relaxation, owing to the position of physiological rest. We have found it far superior to vertical traction with full extension of knee; it is also preferable to the ordinary Buck's extension with the knee extended in a line with the body. Traction on the midthigh, at the site of fracture, is a most inefficient method. The pull comes on the bellies of the muscles that have their origins from the pelvis. There certainly is very little of the pull that is ultimately transferred to the distal fragment. Forty pounds of pull will accomplish infinitely less when the pull comes at the mid-thigh than can be accomplished by five pounds as used in the Russell balanced traction.

Finally, the comfort of the patient should be emphasized. The patients treated by the method we have outlined are thoroughly comfortable; they can be placed on the bed-pan without fear of doing any damage, and pain is almost nil.

SUMMARY

1. Forty-one consecutive cases have been treated by Russell balanced traction.
2. Only one of these was a fracture of the upper third.
3. The oldest patient in the group was eighteen years of age.
4. The youngest patient was nineteen months old.
5. Not one patient has the slightest disability.
6. In no case was there any shortening or malalignment.
7. The average period of disability was nine weeks.

ALCOHOLIZATION OF PERIPHERAL MOTOR NERVES OF THE LEGS IN SPASTIC PARALYSIS OF CHILDHOOD *†

BY RALPH R. FITCH, M.D., ROCHESTER, NEW YORK

In a recent article on "Cerebral Spastic Paralysis in Children", Dr. Edwin W. Ryerson of Chicago has presented this subject in an excellent manner.[1] Since there is already too much repetition in medical literature, and as I concur in a very large degree with the statements of Dr. Ryerson, I shall not attempt to consider the matter as a whole, but shall limit myself to the question of therapy.

Most of the physical disability which is caused by spastic paralysis is due to a lack of balance of power between spastic and non-spastic groups of muscles. Treatment of this condition must therefore have for its main object the equalization of power between these opposing groups. The fundamental to be desired in such treatment is to build up the power of the weaker group or groups of muscles. This can be accomplished only by muscle training. To make such training practical, the spastic muscles must be weakened or paralyzed, at least temporarily. How shall this be accomplished?

Years ago Foerster recommended resection of the posterior nerve roots. The magnitude and uncertainties of this procedure have caused it in large measure to be abandoned. Sympathectomies of Hunter and Royle have proved, in the hands of most surgeons, to be of use in a very limited number of cases. Stoffel's operation, cutting the peripheral nerve supply to spastic muscles, has proved of much value.

When a motor nerve is divided, the result is permanent paralysis as it is not practical to suture such a nerve. If one divides too little of the nerve supply our aim is not attained. On the other hand, if too much is divided, there will result a loss of muscle balance which may prove to be worse than the condition which we are trying to improve.

With these facts in mind, we determined to inject alcohol into peripheral motor nerves with the idea of producing a temporary paralysis of spastic muscles. The operative procedure is to expose the nerves a short distance from where they enter into the muscles, and to inject them with eighty per cent. alcohol.

Between 1924 and 1931, twenty-eight cases of spastic paralysis of legs were operated upon. The desired muscular paralysis was obtained and persisted for three to six months. We believe that this procedure is the method of choice for obtaining relaxation of the spastic muscles, which is the foundation on which successful muscle training of the weaker non-spastic muscles must rest.

* This work has been carried on in conjunction with Dr. Carl T. Harris.

† Presented at the Annual Meeting of the American Orthopaedic Association, Toronto, June 17, 1932.

We recognize that other procedures, such as the division of contracted tissues for the overcoming of deformities, are sometimes necessary adjuncts: but we insist that muscle training, carried on by a competent staff for months or years, is the fundamental agent in helping these unfortunate children.

If this be so, then operations should not be performed upon children who are too young or too feeble-minded to cooperate with those who would help them.

Since it is not practical to use a measuring stick to evaluate the end results in this type of case, I shall not bore you with statistics but merely say that our end results are very much better following alcoholization of the peripheral nerves than after any other method with which we are familiar.

1. RYERSON, E. W.: Cerebral Spastic Paralysis in Children. J. Am. Med. Assn., XCVIII, 43, 1932.

SUMMARY OF DISCUSSION

DR. W. B. CARRELL, Dallas, Texas, after experience with perineural alcoholization in the brachial plexus and the sciatic nerve, would be fearful of recurrences which are to be expected after a Stoffel operation only in proportion to the percentage of nerve sectioned.

DR. FITCH, in closing, admitted the certainty of recurrence, claiming, however, that the paralytic interval permits muscle training to better advantage, and that one may divide too few or too many nerves in a Stoffel operation, either of which is a misfortune.

LEG LENGTHENING WITH NEW STABILIZING APPARATUS

BY EDWARD J. HABOUSH, M.D., AND HARRY FINKELSTEIN, M.D.,
NEW YORK, N. Y.

Of the important recent advances in orthopaedic surgery, none have aroused greater interest than bone-lengthening procedures. The literature on this subject reveals the fact that considerable experimental effort has been expended in attempts to successfully lengthen shortened bones. Among others, such names as Codivilla, Freiberg, Magnuson, Ombredanne, Putti, Steinmann, and Kirschner appear prominently in medical publications. To Abbott, however, is due the greatest credit for devising an improved operative technique, and an ingenious apparatus for maintaining the bones in position during the lengthening procedure. With the appearance of his first article in the January 1927 issue of *The Journal of Bone and Joint Surgery* (*IX*, 128), an added impetus was given this most intriguing subject.

During the past few years, over twenty-five operations for bone lengthening by the Abbott method have been performed at the Hospital for Joint Diseases.* The accompanying chart is a detailed description of only seventeen of these cases which were observed over a sufficient length of time to warrant consideration.

In reviewing the cases shown in Table I, the following complications were encountered:

1. Anterior and medial angulation during the bone-lengthening process.
2. In no case was the separation of the fibular fragments equivalent to that of the tibial fragments.
3. Valgus of the foot.
4. Equinus of the foot.
5. Osteomyelitis.
   A. At the site of the tibial osteotomy.
   B. At the site of the pin insertions.
6. Delayed union and non-union.

A more detailed study of these complications emphasizes the fact that practically every case showed a certain amount of anterior and medial angulation, in some instances reaching as high as thirteen and one-half degrees. We determined our readings from x-ray plates with the use of a transparent protractor with attached threads for measuring purposes. Even one-half of a degree of angulation could thus be determined. In one of our cases there was twenty-five degrees of posterior angulation. In this case the Carrell three-pin method was employed in the hope of preventing anterior angulation.

* From the Orthopaedic Services of Dr. Leo Mayer and Dr. Harry Finkelstein at the Hospital for Joint Diseases.

TABLE I

Summary of Seventeen Cases

									X-Rays									
									Anteroposterior View		Lateral View			Amount of Separation of the Fibular Fragments in Inches				
Patient's Initials	Age	Sex	Case No.	Diagnosis	Findings	Operation	Operative Wounds	Date	Amount of Medial Angulation in Degrees	Amount of Lateral Angulation in Degrees	Amount of Anterior Angulation in Degrees	Amount of Posterior Angulation in Degrees	Amount of Separation of the Tibial Fragments in Inches	At the Site of the Proximal Osteotomy	At the Site of the Distal Osteotomy*	Special X-Ray Remarks	Complications	Additional Data
O. B.	15	M	31378	Old poliomyelitis	Two and a half inches shortening of the left tibia	2–4–31 Abbott lengthening, four-pin method	Two small granulating areas over tibial incision	2–11–31	2.0		12.0		1.0	0	.375		Flexion contracture of the knee	Proximal pin remove 1-25-31 Remaining pins 5-13-31
								2–17–31			19.0		1.0	Obscure	Obscure			
								2–18–31			11.0		1.5	Obscure	Obscure			
								2–27–31	0		13.5		2.125	Obscure	1.0			
								3–20–31	3.0		5.0		2.75	.875	.375			
								5–11–31	4.0		0		2.5	.625	1.0	No callus		
F. B.	16	M	27410	Old poliomyelitis	Right pelvis tilted downward one and a half inches, and three inches of shortening	4–30–30 Abbott lengthening, four-pin method	Healed	5– 8–30		1.5	3.0		.555		312		Extreme equinus of the foot	6-16-30 —three pins removed 6-30-30 —one pin removed
								5–26–30		2.0	3.5		2.0		1.75			
								6–10–30		1.5	2.0		3.125		1.875			
								6–10–30	7.0		13.5		2.0		1.5			
								6–20–30	1.5			5.0	2.125		1.125			
								9– 9–30	7.0			0	1.122		1.0			
								1–16–31	10.0							Bony union		
S. Z.	17	F	29908	Old poliomyelitis	One and three-quarters inches of shortening of right lower extremity	10–15–30 Abbott lengthening, four-pin method 12–10–30 Removal of necrotic bone from the tibia	No data on the chart	10–27–30		1.0	2.0		.25		0		Osteomyelitis of the tibia Delayed union	Pins removed 12-10-30
								11– 4–30	0		6.0		1.375		.875			
								11–25–30	0		8.0		2.625		2.0			
								12– 8–30	2.5		5.0		2.375		1.75			
								12–15–30	9.0		10.0		1.5		1.25	Slipping of fragments No callus		
								12–27–30	6.0		0		1.5		1.0			
								12–13–30	7.5		7.0		1.5		87.5			
M. L.	13	F	29990	Old poliomyelitis	Two and a half inches shortening right lower extremity	10–29–30 Abbott lengthening four-pin method	Healed	11–10–30	2.0		6.0		.875		.25			
								11–22–30	3.5		11.0		2.25		1.0			
								12–13–30	0		1.5		1.75		.375			
								4–21–31								Excellent alignment Bony union		
J. M.	16	M	27083	Old poliomyelitis	Two inches shortening left leg	4–19–30 Abbott lengthening, four-pin method	Tibia denuded for an area about 3 inches long and 0.75 inches wide	4–24–30	1.5		5.5		1.5		.75	Medial displacement .31 inches	Osteomyelitis of the tibia	Pins removed 5–9–30
								4–25–30			7.5		2.0		Obscure			
								5– 5–30			3.0		2.0		Obscure			
								5–12–30	7.0		0		1.125		.75			
								6–20–30	8.0		5.0		1.125		0.25			
								9– 8–30	6.0		5.0		1.0		Obscure			
								8– 8–30	10.0		5.0					Callus formation		
B. W.	12	M	33498	Old poliomyelitis	One inch shortening left lower extremity	6–17–31 Abbott lengthening with an adjustment controlling second and third pins	No data on chart	6–22–31	2.0		Obscure		0.187	0	0			
								7– 1–31	2.0			1.0	0.75	0.25	0			
								7– 7–31	2.0		Obscure		1.187	43.75	0			
								7–12–31	3.0		Obscure		1.187	0.75	0			
								7–21–31	6.5		3.0		1.5	1.375	0	No callus		
								8–17–31	6.0		2.5		1.75	0.875	0			

(Continued on next page)

. Z	11	M	31377	Old poliomyelitis	Two and a half inches shortening	3-4-31 Abbott lengthening, three-pin method	Healed	3-11-31	1.5			Obscure	1.0	0	0.75			Pins removed
								4-3-31	3.0			Obscure	2.125	0	1.5			
								4-8-31	3.0			0	2.25	0	1.137			
								5-15-31	3.5			3.0	2.25	0	1.5			
								5-18-31								Distinct callus formation		
. K.	11	M	32902	Old poliomyelitis	Right pelvic tilt and shortening of the right lower extremity	5-11-31 Abbott lengthening with third pin used as suggested by Carrell	*Sloughing of* skin over medial aspect of shin, exposing bone	5-18-31	2.0			25.0	.312			Medial displacement of the distal fragment	Osteomyelitis of the tibia	
								5-22-31				13.0			0	Anterior displacement of the distal fragment		
								6-2-31				Obscure	1.5	0.75	0	Tongue broken at base		
								6-5-31				Obscure	1.625	0.75	0			
								6-22-31					1.75	0.375	0			
								7-20-31				Obscure	1.5	0.625	0			
								10-21-31			1.5		1.25					
								12-18-31			12.0							
), S.	10	F	32039	Old poliomyelitis	One and one-half inches shortening right tibia	3-18-31 Abbott lengthening, four-pin method 4-10-31 Removal of necrotic bone from tibia	Distal end of proximal fragment found angulated through the wound	5-9-31	3.0		11.0		1.5	0.75		Callus formation Bony union	Osteomyelitis of the tibia	Microscopic se chronic osteom 1-20-31 Pins removed 5
								1-21-32	0									
. R	9	M	28209	Old poliomyelitis	One and a half inches of shortening of the left lower extremity	6-18-31 Abbott lengthening by the four-pin method	Healed	6-26-30	0		0		0.125		0			
								7-3-30	2.0		3.0		0.137		0			
								7-11-30			2.0		2.125		0.875			
								7-18-30	5.0		2.0		1.75		0.875			
								8-12-30	0.0		0		1.75		Obscure	*Good callus formation*		
								11-1-31	7.0									
C	10	M	26653	Old poliomyelitis	Two inches shortening of the left lower extremity	3-10-30 Abbott lengthening by the four-pin method	Healed	3-20-30	0		2.0		1.5		0.312			Pins removed 5
								1-8-30	0		5.0		1.75		1.125			
								1-28-30	5.0		0.0		3.187		2.0			
								5-15-30	3.0		0		2.0		1.0			
								7-1-30	0		0					Callus formation Excellent alignment		
M.	21	F	26651	Old poliomyelitis	Two and three-*quarters inches* shortening of the right lower extremity	1-28-31 *Abbott lengthen*ing, four-pin method 11-11-31 Restabilization, right foot 6-8-31 Sequestrectomy, right tibia 3-18-32 Sequestrectomy, *right tibia*	Area skin necrosis *1.5 inches in* length, middle portion of leg	2-7-31	0		9.0		1.375	0.5	0		Osteomyelitis of the *tibia* Severe equinus of the foot	Pins removed 3 Right foot stab in 1921
								2-9-31			7.0		1.25	0.625	0			
								2-11-31			5.0		1.25	0.625	0			
								2-14-31	0		1.0		1.625	0.875	0			
								2-27-31	0		7.0		2.375	1.25	0			
								3-13-31	0		5.0		2.75	1.5	0			
								3-25-31	0				2.625	Obscure	Obscure			
								3-28-31	6.0		5.0		2.0	1.0	0.75			
								6-6-31	9.0		2.0		2.25	1.0	Obscure			
								1-28-32	0		0							
								9-17-31	9.0							Callus formation		
I	9	F	11290	Old poliomyelitis	Shortening of the right lower extremity	6-18-31 Abbott lengthening, four-pin method	Anterior wound showed a granulating area 3 inches long and 0.5 inch wide	6-22-31	0.0		2.0		0.312	0.625	0.625		Valgus deformity of the foot	Pins removed t
								7-1-31	1.0		Obscure		0.69	0.312	0.625			
								7-9-31	3.5		1.0		1.375	0.75	.125			
								7-15-31	5.0		3.0		2.062	1.0	.125			
								7-21-31	0		1.0		2.125	1.125	.125			
								8-12-31	2.0		1.0		2.25	1.125	.125			
								9-1-31	0			5.0	2.25	1.125	.125			

(Continued on next page)

TABLE I — *Continued*

Patient's Initials	Age	Sex	Case No.	Diagnosis	Findings	Operation	Operative Wounds	Date	X-Rays: Anteroposterior View: Amount of Medial Angulation in Degrees	X-Rays: Anteroposterior View: Amount of Lateral Angulation in Degrees	X-Rays: Lateral View: Amount of Anterior Angulation in Degrees	X-Rays: Lateral View: Amount of Posterior Angulation in Degrees	X-Rays: Amount of Separation of the Tibial Fragments in Inches	X-Rays: Amount of Separation of the Fibular Fragments in Inches: At the Site of the Proximal Osteotomy	X-Rays: Amount of Separation of the Fibular Fragments in Inches: At the Site of the Distal Osteotomy*	X-Rays: Special X-Ray Remarks	Complications	Additional Data
A. D.	10	F	27751	Old poliomyelitis	Two inches shortening chiefly in the right tibia	5-21-31 Abbott lengthening	Completely healed	6- 6-30	0		12.0		1.0	Obscure	Obscure			
								6-16-30	5.0		1.0		1.0	Obscure	Obscure			
								2-14-31	7.0		0					Firm bony union		
								11-25-30	5.0									
H. G.	13	F	33040	Old poliomyelitis	One and three-quarters inches shortening left lower extremity	5-21-31 Abbott lengthening, four-pin method	Wounds entirely healed	5-23-31	1.5		1.0		0.187					
								6- 2-31	5.0		0		1.25	0.375	0.25			
								6-15-31	5.0		0		2.25	0.75	0.75			
								6-19-31	0		0		2.437	Obscure	Obscure			
								7-15-31	0		0		2.5	1.0	0.5			
								9- 8-31	0		2.0		2.5	1.0	Obscure			
								10-29-31	0		0		2.375	Obscure	Obscure	Firm bony union		
								8-10-31	0		0		2.375	Obscure	Obscure			
								12- 9-31	0		0							
F. B.	17	F	26192	Old poliomyelitis	Three inches shortening of right lower extremity	3-5-30 Abbott lengthening, right tibia 2-14-31 Sequestrectomy, right tibia	Superficial wound mid-tibia, one and a half by one-half inch by one-quarter inch, with grayish necrotic tissue at base which was excised	3-20-30	0		Obscure		1.562	1.5		Medial displacement of the distal fragment	Osteomyelitis of the tibia, both middle and distal aspects Non-union of the tibia	
								3-12-30	0				0.75	0.5		Medial displacement of the distal fragment		
								4- 8-30	0		Obscure		2.75	1.875				
								5- 8-30	7.0		13.0		2.75	2.0				
								5-12-30	5.0		2.5		2.75	2.0				
								5-31-30	3.0		0		2.75	Obscure				
								9-30-30	9.0		1.5		1.5	Obscure				
								8-29-30	12.0		7.0		Obscure	Obscure				
								1-20-31	0		0					No callus present		
								7-25-31	8.0		0					Callus present		
								8-25-31	11.0		0					Chronic osteomyelitis with sequestrum		
K. B.	16	F	31475	Old bilateral ankylosis following epiphyseolysis	Shortening left lower extremity 1.75 inches	2-18-31 Abbott lengthening, four-pin method 3-9-32 Albee bone graft, left tibia, for non-union	Area of pressure necrosis over the proximal fragment	2-27-31	5.0		14.0		1.0		0.5		Non-union of the tibia	Pins removed 5-18-31 Pathological specimen removed at operation for non-union 3-9-32 Report, fibrous tissue Slight tendency of the tibia to angulate anteriorly
								3- 7-31	13.5		11.25		1.375		1.0			
								3-20-31	3.0		12.0		1.75		1.25			
								4- 8-31	8.0		0		2.5		1.75			
								5- 4-31	12.0		0		1.625		1.25			
								5- 9-31	5.0		0		1.625		1.0			
								7-14-31	7.0				1.375		0.75	Slight callus present		
								9- 8-31	15.0		0							
								10-17-31	16.0		0							
								1- 6-32	12.5		0					Slight callus formation		

* In several cases the fibula was osteotomized at two different levels.

It is our opinion that anterior angulation is due to rotation downward of the distal fragment, while the proximal fragment remains fixed. This point may well be illustrated by one of our cases, in which, despite an increasing flexion deformity at the knee tending to depress the distal end of the proximal fragment, the distal fragment remained angulated.

It has been our experience that the Abbott apparatus does not sufficiently control the angulation during the lengthening procedure because the pins bend. This is particularly true of the lower pins, since there is a greater distance between the leg and lower movable blocks which affords the pins a longer lever arm for bending. In using the Abbott apparatus with angulation developing, one may readily appreciate how the proximal pin in the distal fragment would tend to exaggerate the deformity with each additional turn of the nut.

The Abbott apparatus also permits medial angulation. We have observed that, while the pins and lower movable blocks are parallel at the time of insertion, they do not remain so during the lengthening process. Resistance by the soft tissues causes the distal fragment of the tibia to angulate medially. In turn, the lateral ends of the lower pins and lateral movable block are checked temporarily, while the medial ends of the pins and movable block continue to move downward. The slack is taken up by the spring between the lateral movable block and nut. If uncorrected, the degree of medial angulation will be accentuated.

After careful measurements from x-ray plates following bone-lengthening operations by the Abbott method, the authors noted that in no case was the separation of the fibular fragments equal to that of the tibial fragments. This was primarily due to the fact that the pins were inserted only into the tibia, and secondarily to the resistance offered by the periosteum of the tibia, interosseous membrane (even though they were divided), undivided lateral compartment fascia, muscles, and other fascial attachments to the fibula. Dividing the periosteum of the tibia and interosseous membrane at the same level, over the site of the tibial osteotomy as advocated by Abbott, does not release the tension upon either osteotomized tibial or fibular fragments. The fibular fragments are bound to each other by the interosseous membrane, because it is divided above the site of the fibular osteotomy. This is also true of the periosteum covering the distal fragment of the tibia for it, too, is bound to the upper fragment of the fibula by the interosseous membrane between the fibular osteotomy and the level at which the periosteum was divided.

Because of this discrepancy in the separation of the fibular and tibial fragments, the tip of the external malleolus is higher than under normal circumstances; this places tension on the fibulocalcaneal, talocalcaneal ligaments, and peroneal muscles, resulting in a valgus deformity of the foot. This occurred in two of our cases. Another factor favoring valgus deformity can be ascribed to medial angulation of the distal fragment of the tibia, the upper end of which is inclined medially while the lower end is displaced laterally.

Equinus deformity of the foot occurred in two of our cases, one of which required a subsequent restabilizing operation. In one of our unreported cases, the plantar flexor muscles were so resistant that a right-angle position of the foot was maintained only at the expense of an area of pressure necrosis on the sole of the foot. It is also important to bear in mind that in cases of anterior angulation, the lower end of the distal fragment of the tibia is displaced backward, thus favoring equinus deformity. It is also possible that the undivided posterior investing deep fascia likewise may be a restraining force favoring equinus deformity. In a certain percentage of cases of leg lengthening, the Abbott apparatus does not control the position of the foot. Even Abbott accepts this stand and "considers it unwise" in dealing with the cases of infantile paralysis to stabilize the foot before the operative lengthening, because, in a number of cases in which the foot was previously stabilized, restabilization had to be carried out at a later date.

Osteomyelitis at the site of the tibial osteotomy occurred in six of our cases, five of which were due to anterior buckling of the tibial fragments. It is evident that an increasing anterior angulation may produce pressure necrosis of the overlying tissues, exposing bone, and thereby converting a presumably simple into a compound fracture. In the case treated by the Carrell three-pin method, in order to avoid anterior buckling, not only was there twenty-five degrees of posterior angulation, but also osteomyelitis of the tibia due to pressure necrosis of the overlying skin. The force exerted by the pin was so great that a fracture of the proximal tongue of bone also ensued. Abbott reports a similar experience.

Osteomyelitis at the site of pin insertion occurred in one case. As a result of this complication, we have adopted the use of thin Kirschner wire as a substitute for the heavier pins.

Delayed union was present in four cases. In one the fragments were displaced during the final application of a plaster cast before solid union had occurred; another was the case previously mentioned, in which there was a fracture of the proximal tongue of the bone. Both of these ultimately united. Two other cases resulted in non-union, necessitating subsequent bone-grafting operations.

Although delayed union and non-union may be attributed to many causes, it is the opinion of the authors that two of the contributory causes can be ascribed to:

(1). The improper alignment of the fragments.

(2). The severance of the periosteum at the point of osteotomy of the tibia as recommended by the Abbott plan.

While the periosteum is accepted by some as being only a limiting membrane, lacking in osteogenetic function, there is no doubt of the osteogenetic power of its deeper stratum.

In analyzing these various complications, it was clearly evident, therefore, that in the Abbott method of leg lengthening the main difficulties encountered by the authors were due to the following causes:

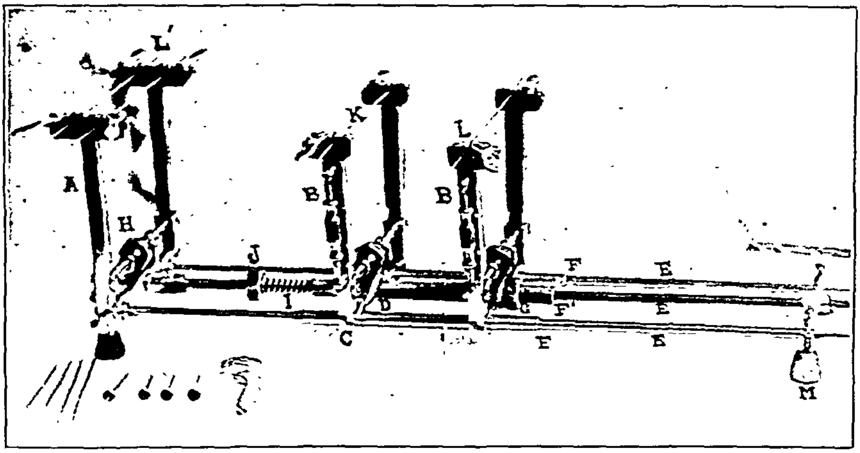

FIG. 1

A. Proximal uprights.
B. Middle and distal uprights which are adjustable vertically.
C. Hinge joints.
D. Cross-bars.
E. Longitudinal rods.
E'. Threaded longitudinal rod.
F. Steel tubes which ride freely on longitudinal rods.
F'. Threaded steel tube which rides freely on the threaded longitudinal rod.
G. Nuts on each side of distal cross-bar which fix it.
H. Turnbuckle screw arrangements which spread the lateral uprights and place tension on the Kirschner wires, *K*.
L. Single clasps for holding Kirschner wire.
L'. Double clasps for Kirschner wire.
I. and *J*. Spring and nut for lengthening.
M. Rubber peg.

(1). That the fragments of the osteotomized tibia could not be maintained in proper alignment with absolute certainty.

(2). That the separation of the fibular fragments was not equal to that of the tibial fragments.

(3). That insufficient attention had been given to the resistance offered by such soft-tissue structures as fascia, interosseous membrane, and periosteum.

(4). That proper position of the foot could not be maintained, and, finally,

(5). That too long a period of time elapsed in the average case before complete bony union occurred.

In an attempt to overcome these difficulties, various investigations, together with cadaver dissections, were undertaken. In the course of these experimental studies, certain difficulties were encountered, which could be directly attributed to the resistance offered by soft-tissue structures. Although all soft tissues yield to a certain extent when traction is applied, fascia yields with great resistance. This was definitely proved by Gratz who demonstrated that, while it has an elasticity range, its tensile strength is that of steel wire from a standpoint of specific gravity. If undivided, it not only resists much of the force used in lengthening, but tends to angulate the distal fragment, for the reason that in the leg the

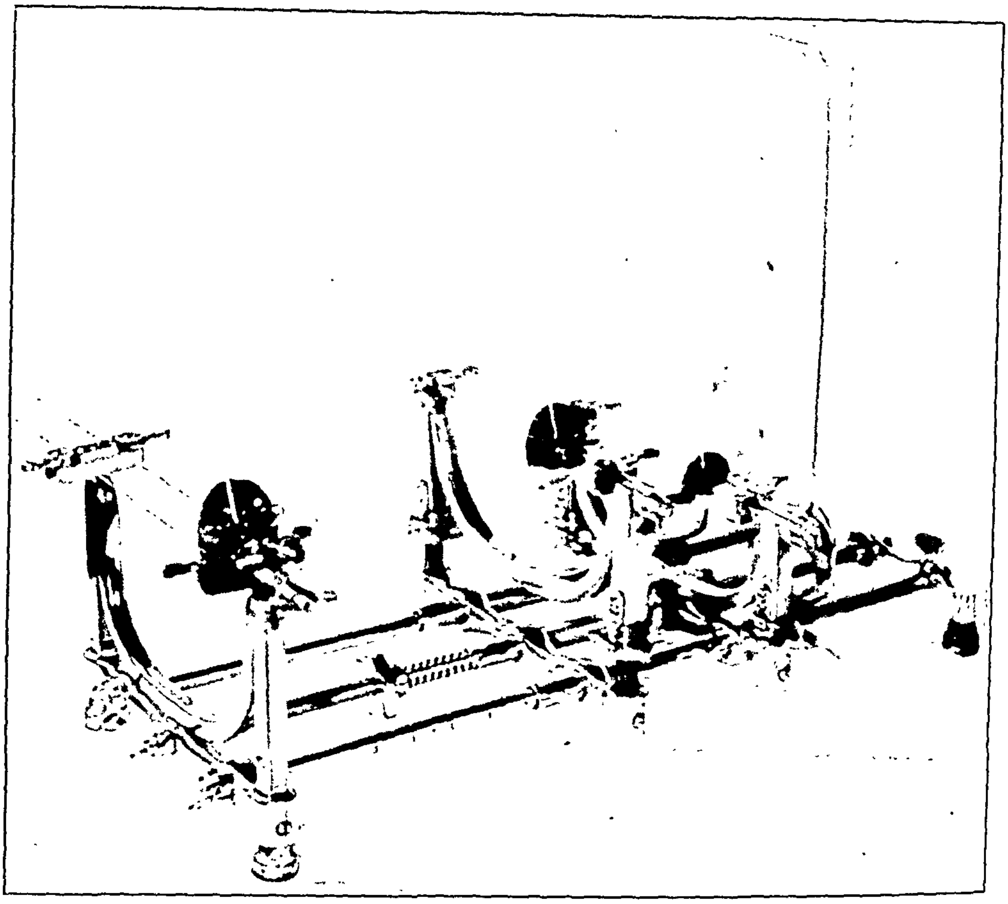

Fig. 2

In the latest model the uprights and cross-bars are fixed, the hinge joints and turnbuckle screw arrangements for spreading the uprights having been eliminated. The wire is made taut by a turnscrew in line with the wire. For controlling the medial angulation we have adopted the use of shields that are attached to the pins on each side of the leg. These shields also prevent the leg from shifting on the wires.

tibia is eccentrically placed, the soft tissues being mainly posterior and lateral. In all probability, the severe pains occurring during the lengthening process, a rather constant feature in this series of cases, were due to the tension on the muscles by the undivided, taut fascial membranes from which some of the muscles derive their origin. Abbott, in his latest contribution, evidently has realized the importance of this procedure, for he likewise advocates the division of the deep anterior fascia, the anterior and posterior fibular intermuscular septa, in addition to division of the interosseous membrane.

The ultimate result of these investigations led to:

(1). The devising of a special stabilizing apparatus by means of which the osteotomized fragments could be controlled at will, with the tibia and fibula maintained in the same relationship as exists normally so as not to disturb the mortise of the ankle, and with the foot held in proper position during the lengthening process.

(2). The use of Kirschner wires instead of the heavier pins.

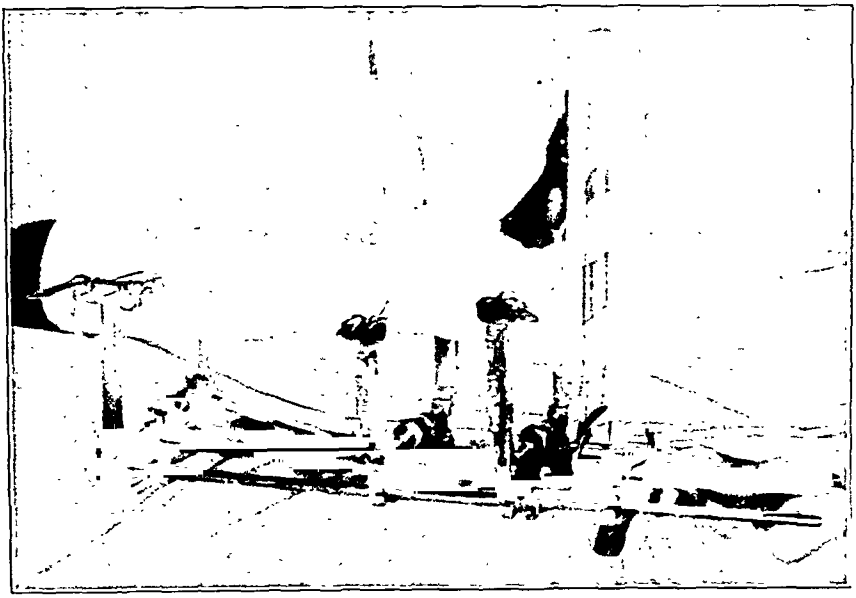

FIG. 3
Leg during the lengthening process.

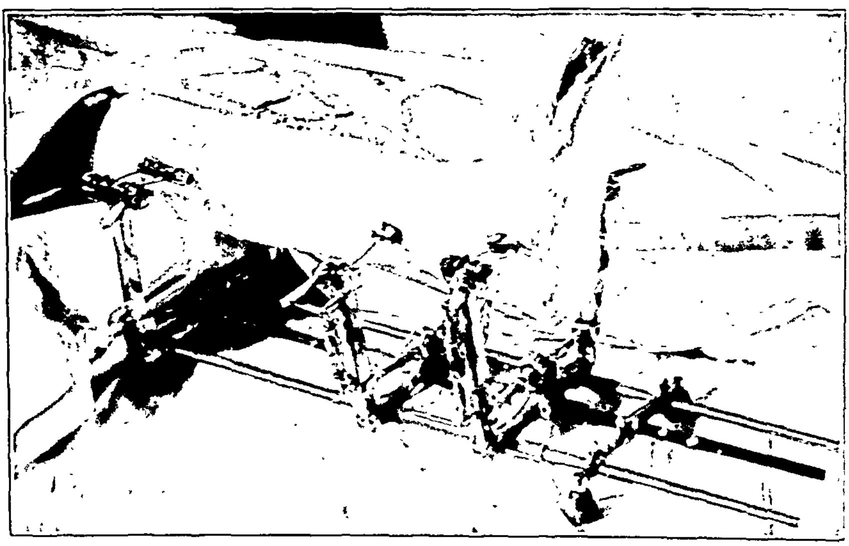

FIG. 4
After the desired lengthening has been procured a plaster bandage is applied. This is done with great ease while the limb remains in the apparatus, as there are no obstructing longitudinal rods. Clasps and longitudinal steel shafts to retain the separation and tension on the wires are incorporated within the bandage.

FIG. 5

The limb is removed from the apparatus after the plaster has been allowed sufficient time to dry. To further insure against slipping of the wires they are bent over the clasps and an additional few turns of plaster bandage are applied.

A. Longitudinal steel shaft.
B. Clasps for maintaining tension on wires.
C. Kirschner wires bent over the clasps and plaster.

(3). Insertion of one pin into the distal fragment of the tibia and one into the os calcis. This insures better control and alignment of the fragments in that it creates a shorter lever arm for the angulating forces and a longer lever arm for the opposing forces,—such as, the overlying tissues, skin, and pin. It also controls the position of the foot.

(4). Certain definite changes in the technique of the operation,—such as a more thorough division of the fascia, interosseous membrane, and complete circumferential division of the periosteum of the tibia and fibula, all at the same level, in a non-binding zone at the point of fibular osteotomy.

In addition to the transverse incision of the interosseous membrane and complete circumferential division of the periosteum of tibia and fibula, we incise transversely the entire lateral peroneal compartment fascia, the deep anterior and posterior investing fascia, and the two fascial partitions which divide the posterior osteofascial compartment. This is all accomplished at the same level about two inches above the tip of the external malleolus. No difficulty is here encountered, for the muscles in this region approach their tendinous insertions and are bound by a very loose connective tissue called paratenon. By osteotomizing the fibula at the same level, the fragments are more easily separated, since every restriction has been overcome. This is also true of the periosteum of the tibia and, by dividing it at the same level instead of at the site of the tibial osteotomy, as suggested by Abbott, the periosteum above is preserved *in toto,* so that it may be used to amply cover the gaps of the tibia resulting from the elongation process, thus favoring a more rapid deposition of callus and hastening bony union. Another advantage of this change in technique is that a sleeve of periosteum is created into which the distal fragment of the tibia can glide.

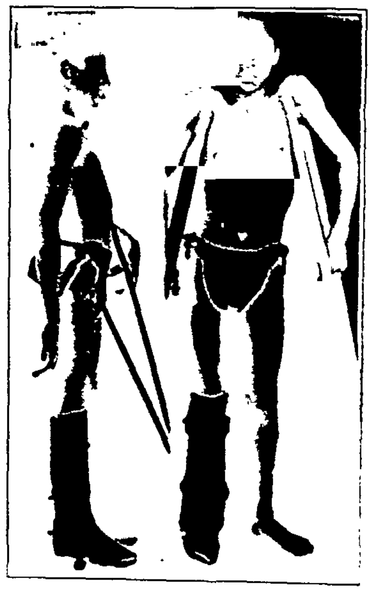

FIG. 6

A walking iron is incorporated into the plaster and the patient is immediately allowed to walk.
This further stimulates the deposition of callus and hastens bony union.

THE APPARATUS

The apparatus specially designed by the authors consists of three pairs of lateral uprights, each of which is attached at its lower end by a hinge joint to a horizontal cross-bar. The upper ends of the uprights are T-shaped. The horizontal part of the T of each of the proximal uprights has two clasps for gripping the Kirschner wire. Each of the second and third pairs of uprights holds one wire; while the proximal pair of uprights is fixed, the lower two are adjustable vertically for controlling anterior angulation of the distal fragment. The distal pair of uprights is lower than the other two for receiving the pin which inserts into the os calcis. To the proximal cross-bar are fixed three longitudinal rods, twenty-one inches long, at right angles to it. The center

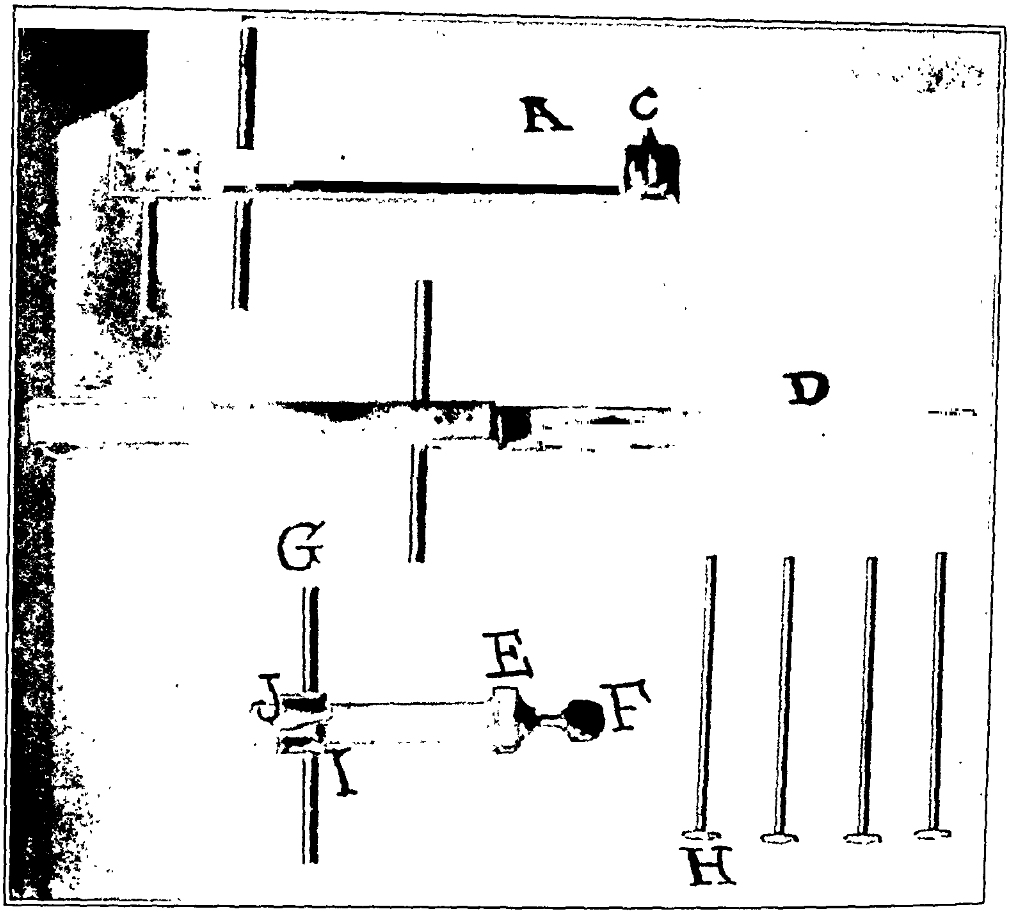

FIG. 7

A. Proximal part of guide.
B. Distal part of guide that telescopes into proximal part *A*.
C. Turnscrew which fixes the telescoping parts *A* and *B*.
E. Vertical shaft that moves freely on *D*, and turnscrew *F* for fixing shaft in the desired position.
I. Carriage holding cylinder for pin inserted into the os calcis. This moves freely on shaft *E* and is fixed by turnscrew *J*.
G. Cylinders for pins.
H. Tubes for Kirschner wires. These telescope into cylinders.

rod is threaded. Three steel tubes, seven inches long, carry the second cross-bar to which they are fixed and move freely upon the rods. The center tube is threaded and has two threaded nuts which fix the third cross-bar, one on each side. There are three holes in the third cross-bar which permit it to move freely on the tubes, making the distance between the second and third cross-bars adjustable, thus creating a freely movable carriage, holding the lateral uprights in a fixed parallel manner. Tension of the Kirschner wire is procured through the lateral uprights by means of a turnbuckle screw arrangement between the uprights. By fixing the turnbuckle screw arrangement to the cross-bars, lateral stability of the uprights is secured. Lengthening is procured by a nut and spring on the center rod between the first and second pairs of uprights. Distal to the moving carriage on the three rods is a cross-bar which may be made fast by turnscrews. At each

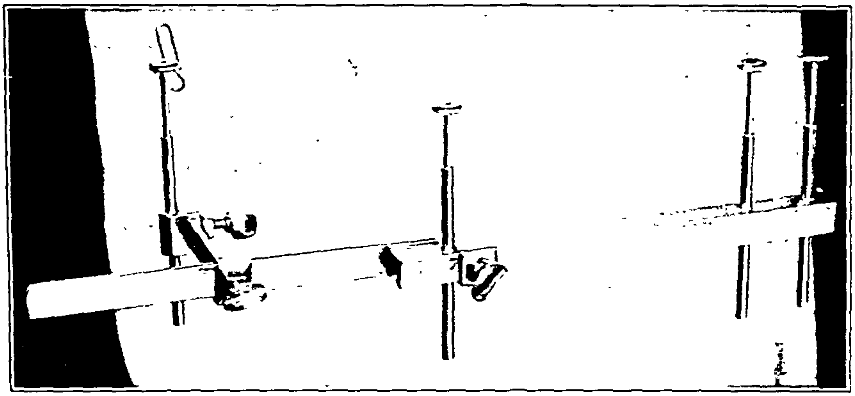

FIG. 8
Guide assembled and ready for use.

end is a rubber peg. The proximal cross-bar is also supplied with rubber pegs, one at each end. These pegs are all of equal length, so that the apparatus may rest on any flat surface. To the lower end of the movable carriage is attached a splint to support the forefoot and toes.

We subsequently modified the apparatus.

The distance between the first two pins is fixed. Between the proximal pins and pin three, as well as between pin three and pin four, the distance is adjustable. Tube for pin four is made adjustable in a vertical direction. For the Kirschner wire removable tubes were made that fit into the guide. This makes it applicable for either pins or wires.

DESCRIPTION OF THE OPERATION

On the lateral aspect of the leg, just above the subcutaneous surface of the fibula, through a three-inch incision, the deep investing fascia of the lateral compartment is exposed. A longitudinal slit is made into the roof of the lateral compartment fascia and in the order given the following structures are divided:

1. Deep investing fascia of the anterior and lateral compartments.
2. Anterior fibular septum.
3. Posterior fibular septum.
4. Periosteum on the lateral surface of the fibula together with the floor of the lateral compartment fascia.
5. Posterior investing fascia and two fascial partitions which divide the posterior osteofascial compartment.
6. Lengthening of the tendo achillis by the Hoke method.
7. Periosteum on the medial surface of the fibula, interosseous membrane, and transverse incision of the periosteum on the lateral and under surface of the tibia.

These structures are all divided at the same level, about two to three inches above the tip of the external malleolus. In the same plane, through the same incision, the fibula is osteotomized obliquely.

The skin is not only pulled toward the center of the leg, but also toward the crest of the tibia, and with our special guide through stab incisions two wires are driven into the proximal end of the tibia, one into the lower end, slightly below the division of the periosteum on the lateral surface of the tibia, and one into the os calcis. An electric drill is used and the wires are driven through with great ease and rapidity.

The apparatus is applied and a slightly curved, seven-inch incision is made through skin, superficial fascia, and periosteum, exposing the tibia. In the lower end of the wound where, on the lateral surface of the tibia, the periosteum had been transversely incised, it is now completely divided and entirely stripped from the tibia for a distance of about three inches. Above this point on the anterior aspect of the tibia the periosteum is stripped sufficiently to permit the longitudinal bone cuts.

The authors consider this change in technique of the greatest importance, since it not only entirely eliminates the resistance of the periosteum, but also preserves it *in toto* to amply cover the gaps in the tibia produced by the elongation process, where its osteogenetic stimulation is most necessary; this favors the more rapid formation of callus and thus hastens bony union. Should the periosteum of the tibia be divided at a level independent of that of the osteotomized fibula and at which all the fascial structures were divided, the periosteum of the tibia would be held by the fascial structures between their levels of division. Should a higher level be chosen, the muscles deriving their origin from these fascial structures would increase the resistance to the lengthening process and cause pain.

The tibia is osteotomized so that the tongue on the distal fragment is made to overlay the tongue on the proximal fragment. The longitudinal bone cuts are made four inches long, and the lower cross cut of the tibia is three inches above the level at which the periosteum was divided. This gives a four-inch tongue of bone which allows for three inches lengthening and one inch overlap.

A drain to prevent postoperative swelling of the foot is inserted into the lower end of the wound which is closed in layers. The drain is removed in twenty-four hours.

SUMMARY

We believe that by the use of our apparatus, Kirschner wires instead of the heavier pins, the insertion of a wire into the os calcis and one into the distal fragment of the tibia, more thorough division of the fascia, division of the interosseous membrane, and complete circumferential division of the periosteum of the tibia and fibula, all at the level of the fibular osteotomy in a non-binding zone, better control and alignment of the fragments is maintained; therefore, osteomyelitis is less apt to occur, the same relationship between the tibial and fibular fragments is assured during the lengthening process, and the foot is held in a more normal position.

The apparatus is designed to rest on any flat surface so that it is no longer necessary to suspend the limb from an overhead frame or tie the

patient to a bed during the lengthening. Plaster may also be readily applied with great ease while the limb remains in the apparatus, so there is no danger of slipping of the fragments; this also permits the patient to begin walking at an earlier date.

By the various changes in the technique of the operation, not only is the resistance of the fascial structures entirely overcome, thereby diminishing the amount of pain to the patient caused by the lengthening process, but also the periosteum is preserved so that it may amply cover the gaps in the tibia resulting from the lengthening process.

The cases that have been treated by this new method form the basis of a paper that will be published at some subsequent date.

In concluding, the authors wish to reiterate the fact that credit for developing the bone lengthening procedure in this country rightfully belongs to Abbott and his coworkers, and that the intention of this contribution is not in a spirit of criticism, but rather to emphasize the importance of certain additional technical and mechanical features, which in the authors' hands have reduced the number of complications previously encountered.

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A TECHNIQUE FOR THE OPERATIVE CORRECTION OF BOW LEGS

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It may be accepted that after a certain age limit, or in the presence of marked sclerosis, or in the case of severe *saber-shin deformities*, the correction of bow-leg deformities by osteoclasis is not feasible and resort must be had to open operation. In this event the usual method is simple transverse osteotomy. When the deformity is considerable and especially when, as is usually the case, the deformity represents a triple one of lateral bowing, anterior bowing, and torsion, the consequent adjustment at the site of division of the tibia leaves a *minimum of contacting* bone surface —really only an edge or a point contact—with extreme instability; and the maintenance of any apposition till fixation dressings are in place is precarious. This, coupled with the fact that the bone division is made through an area of sclerosis, avascular and often almost eburnated, has made the healing process slow, with delayed union not infrequent and non-union often reported.

Cognizant of this situation, Schwartz advocated the excision of such a wedge-shaped or cuneiform bone segment as would provide full-width apposition of bone surfaces after correction of deformity. The slight resultant shortening, however, leaves enough slack so that maintenance of apposition is rather difficult, as is also the determination of the exact amount of resection which will correct all three deformities.

Even more difficult, in a sclerosed, curved, and twisted bone, is the production of multiple longitudinal lines of osteotomy, that will render it sufficiently plastic to permit complete realignment, as recommended by Haas. Another method that has been advocated,—namely, reducing the entire shaft subperiosteally into a mass of small bone fragments—seems fraught with too great risks to be popular.

Several years ago, in the readjustment of a malunited oblique tibial fracture, it was observed that a simple swiveling motion of the two fragments had resulted in angulation in two planes, plus torsion. This fact suggested that by making a long osteotomy in the proper plane, and with the necessary degree of obliquity and swiveling the two fragments on each other, a triple deformity would be corrected with ensuing wide apposition of cut surfaces that would extend in a rachitic bone beyond the area of maximum sclerosis, and so would favor prompt repair. If the deformity were mainly of the saber-shin type, the oblique osteotomy would be nearly in the sagittal plane, and as long as possible; if mainly a varus or valgus, in nearly the coronal plane. If a considerable element of torsion prevailed in the deformity, the osteotomy would be less acutely oblique, so that the swiveling motion should add more of a rotation element. If the deformity included anterior as well as lateral bowing, the cut would be somewhere

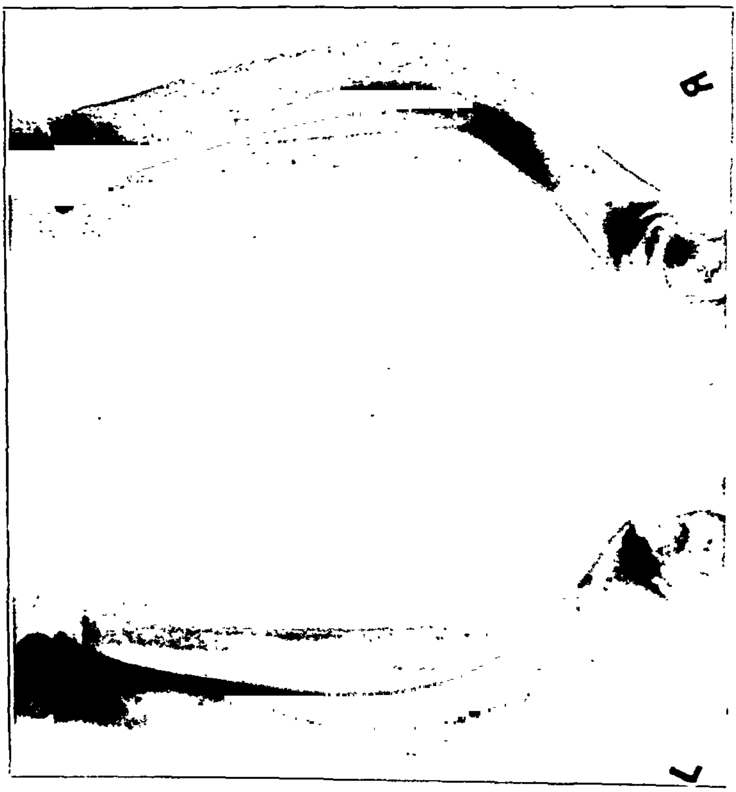

Fig. 1

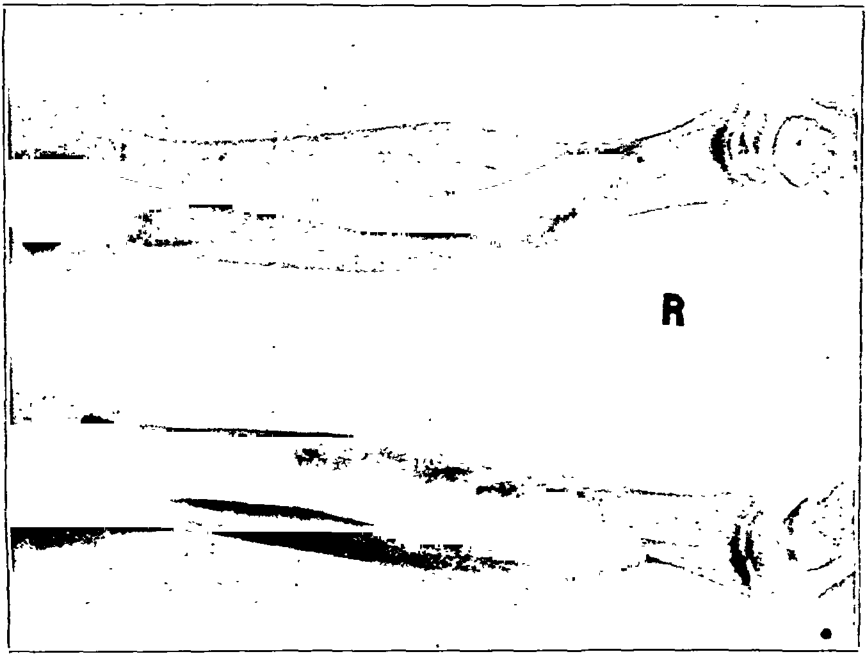

Fig. 2

Fig. 1. M. S. Extreme saber shins or pure anterior bowing. See Fig. 2.

Fig. 2. M. S. After oblique swiveling osteotomy. Ankles restored to normal static plane.

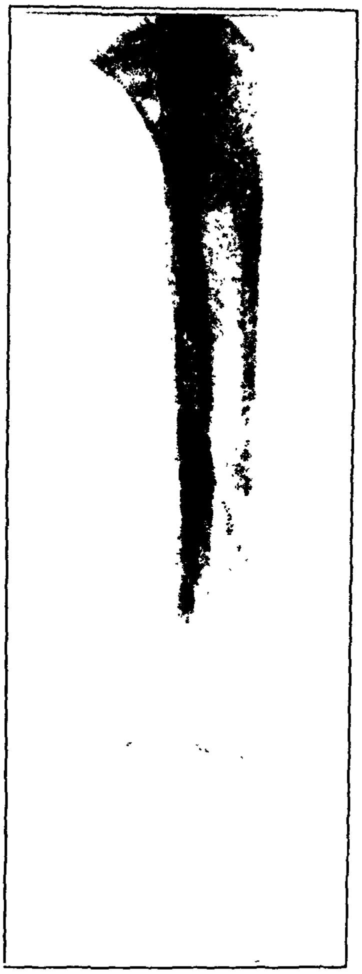

Fig. 3

F. A. Left leg, lateral view, showing direction of osteotomy after correction of varus bowing plus inversion, by oblique bone cut.

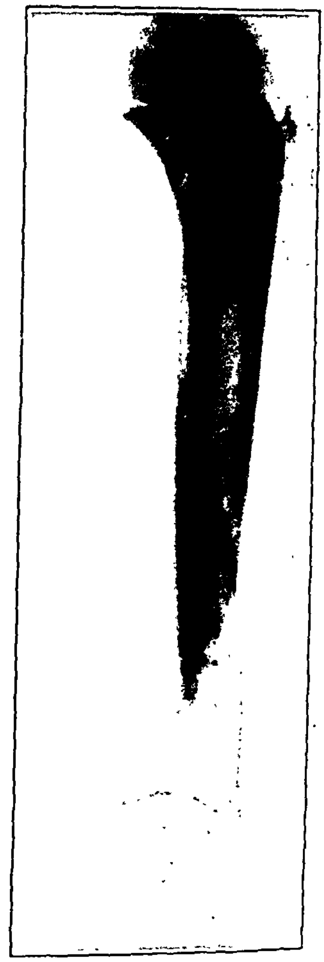

Fig. 4

F. A. Right leg, lateral view, showing swiveling in plane to include correction of anterior bowing as well as torsion and varus.

between the coronal and sagittal planes, so that correction of both forms of bowing would result from the swiveling adjustment.

Such a conception seemed to include the following essential desiderata: (1) a plan geometrically simple; (2) the minimum necessary cutting of bone which will still allow realignment in all planes; (3) sufficient apposition or contact of fragments to insure certain and prompt union, with (4) adequate control until fixation dressings are in place.

Acting on the above theory, the writer evolved, three years ago, a procedure which in this period of its application has seemed to meet the above qualifications in a most satisfactory manner and to have been supported by its results in a series of about twenty cases. Experience with it has emphasized, in addition to the simplicity of the operative technique, the following definite advantages:

After the osteotomy, there are wide contacting surfaces of both cancellous and cortical bone, held in apposition by ligature, and finally adjusted to the desired position of correction as the plaster dressings harden, eliminating the uncertainty of eventual good contact and apposition.

As the two fragments constitute inclined planes or wedges in apposition, the circular approximating ligature prevents overriding and shortening.

No periosteal reflection is necessary with very little expected interference with this part of the bone circulation.

The line of osteotomy, instead of being restricted to the dense and sclerosed area at site of maximum deformity, extends well into normal bone areas above and below.

These considerations all probably have some part in the unusually rapid consolidation or healing that has been observed, and in the apparent strength of the healed fracture at an unusually early date. In about half the cases the plasters have been changed for observation at the end of two weeks. In every instance sufficient consolidation was found to have occurred to give the impression of union and to indicate that it would have been difficult to change the position except under an anaesthetic. After two weeks more in plaster, all splinting was discontinued, freedom of the bed allowed, and massage given for another two weeks when walking was started. Pain and tenderness at operative area was apparently not present and all cases proved the completeness of union by the absence of any subsequent deformity, observation on most having continued up to present time, with about half of the total series now at least two years postoperative.

DETAILS OF OPERATION

The middle third of the tibia is exposed through a curved incision, the belly of which lies over the extensor muscles, and under the mid-point of which the fibula may be exposed when indicated. By more or less blunt dissection the shaft of the tibia is freed from the soft parts, the periosteum not being reflected save where it comes away with the muscle attachments. Previous study of leg and films has indicated the plane of osteotomy, and

Fig. 5

J. A. Original condition including high-grade varus, considerable torsion in inversion, and moderate anterior bowing.

FIG. 6
J. A. After healing of a moderately long oblique swiveling osteotomy. Note absence of torsion as well as restoration of transverse planes and weight-bearing lines.

the tibia is accordingly cut through in this long oblique plane, using a wide thin osteotome or the motor saw, following which, as a rule, a manual fracture of the fibula is produced, though with very severe deformity a complete division by osteotomy may be preferable. The cut surfaces of the tibia are then rotated on each other to the degree necessary for correction and the amount of projection of the extreme ends of each fragment is noted. When this is considerable, a little trimming may be done. The fragments are then returned to their original position, a No. 2 plain catgut ligature is passed around both at their mid-point and tied tightly. This insures continued apposition of bone with prevention of any soft-tissue interposition before the final adjustment for correction is made, yet leaves the leg in a plastic state for eventual permanent realignment by swivel movement at the fracture site. After treatment of the other leg in same manner and closure of wounds, a plaster fixation is applied in three segments, one extending from upper thigh to a point below the knee, and a second from toes to a point above the ankle. As these two segments harden, the lower is brought into the desired alignment with the upper, the apposition ligature permitting the swivel motion to take place at the fracture site without separation of the cut surfaces. A few more turns of plaster in the middle complete the fixation dressing.

ELABORATION OF THEORETICAL PRINCIPLE

Inasmuch as the simple statement of the principle of this osteotomy may not leave its actual application to the various types of deformity entirely clear, and as it is necessary to select a proper plane for each type, a more elaborate development of the reasoning may be appropriate.

The following conception has seemed to be the most instructive in working out the operative plan: Assume first a Z-shaped osteotomy such

as would be done in shortening or lengthening a long bone. If the two long cut surfaces were rotated in apposition around an axis perpendicular to the mid-point of these surfaces, a simple angulation would result. If such an osteotomy were done in the sagittal plane of a bone with just an anterior bowing, a posterior angulation could be produced which would compensate for the amount of original deviation. In the same way a pure lateral bowing, such as a varus deformity, would be compensable by an osteotomy done from side to side or in the coronal plane, with production of angulation by rotation of the cut surfaces. It next becomes apparent that, if the osteotomy cut were made in a plane half way between sagittal and coronal, the angulation which could be produced by rotation would be fifty per cent. anteroposterior and fifty per cent. mesiolateral, and would be relatively more of the one and less of the other as the cut deviated either toward the sagittal or toward the coronal plane. Thus would compensation and realignment be obtained in a case of marked anterior bowing plus a little varus or valgus; or, again, in a case of marked varus or valgus deviation, plus a little anterior bowing.

FIG. 7
J. A. Lateral view after healing, showing correction of anterior bowing as well as of other deformities.

Now assume a simple transverse section across the shaft of the bone, with rotation of the lower fragment on the upper around the central longitudinal axis of the shaft; the only resultant deviation would be torsion in inversion or eversion. Should such a section, instead of transverse, be slightly oblique, there would be a lesser degree of inversion or eversion on rotation at the cut, but a new element of angulation or bowing. By the same token, should a Z-shaped longitudinal section be changed to an oblique, an element of torsion or version would appear, increasing relatively as the cut is made more oblique, with progressive decrease in amount of angulation produced as the obliquity approaches the transverse.

So by shading the obliquity of an osteotomy in the various possible directions, various combinations of compensatory deviations may be produced, fitting any case requiring realignment for torsion plus either forward or sidewise bowing, or all three. The writer has but rarely encountered a rachitic bent bone in which there was not some amount of torsion between foot and knee, and with a very long oblique osteotomy a minimum amount

Fig. 8-A

Fig. 8-B

J. A. High-grade combination of all deformities—before and after operative correction. See Figs. 5, 6, and 7.

of corrective torsion may be obtained. Conversely, there has not appeared a case of torsion so great that a plane of section sufficiently oblique to correct any accompanying bowing deformities as well is not easily obtained, at the same time extending a distance up and down the bone sufficient to bring the ends of the cut beyond the area of maximum sclerosis. Of course in practice the torsion deformity is never the major one, and is corrected by such a *fractional* amount of rotation that no geometric calculation of osteotomy for the complicated but rather merely the choice of that one of the two possible oblique shifts,—*i. e.*, that producing inversion or eversion, when the surfaces are rotated to correct the other one or two deformities prevailing.

Fig. 9

E. P., age thirteen. Sharp varus with painful pseudarthrosis between calcaneal and lateral malleolus.

Fig. 10

E. P. After swiveling osteotomy.

SUMMARY

A method of corrective osteotomy for the complicated deviations of the rachitic tibia has been described, which seems to include a minimum of operative interference in the bone, universal applicability, adequacy of correction, and prompt and certain consolidation, with notable shortening of postoperative immobilization and convalescence.

The method has been applied to about twenty cases and has been uniformly successful. Complications in the way of wound infection occurred twice, both times on one side only in a bilateral case, and though a low-grade osteomyelitis prevailed, as evidenced by discharge of a small sequestrum, solid union occurred and the sinus closed permanently after a few months with no other treatment than simple dressings. Although complete correction prevailed in all cases of the series, the most striking result seemed to be the rapidity of healing.

THE TENDO PATELLAE

A Roentgen Consideration of Its Length *

By Paul O. Snoke, M.D., Lancaster, Pennsylvania

The object of this presentation is to show a progressive increase in the length of the patellar tendon after the close of the growth period.

The Dutch roentgenologist, Murk Jansen,[1] after long study of the knee joint, described "patella alta vera",—*i.e.*, a true high-lying patella, which may be productive of discomfort due to pinching of synovial fringes or reflections. It logically follows that if one has a high-lying patella, the tendo patellae must be longer than normal. The length of the normal patellar tendon was not ascertainable from the literature and recourse was made to mensuration of normal roentgenograms.

Our attention was attracted to this matter by the case of an old lady † who fell upstairs, striking both knees simultaneously on a higher step; roentgenograms were secured of both knees and, following a fatal issue, we were permitted an autopsy (*Figs.* 1 and 2). We found ourselves in posses-

Fig. 1

Note location of patella and shredded patellar tendons. Position of condyles correctly superimposed shown in left knee.

* From the X-ray Department of the Lancaster General Hospital. Dr. Charles Baer rendered valuable assistance in mensuration.

† Referred for diagnosis through the courtesy of Dr. J. L. Atlee, Sr.

sion of roentgenograms of bilaterally ruptured patellar tendons and great diagnostic difficulties in that she had no normal knee with which to make comparisons. We did discover, however, that numerous soft structures were visualized about the knee joints in good lateral roentgenograms and chief among them was the patellar tendon. In order to determine the normal length of the patellar tendon, we set about the mensuration of normal lateral roentgenograms.

FIG. 2
Photograph at autopsy. The ruptured ends of both patellar tendons are visible.

THE LENGTH OF THE PATELLAR TENDON

One hundred normal lateral knee roentgenograms were selected from our files. Boon-Itt's [2] patellar index was calculated and found to be correct. When serious deviation occurred it was frequently due to unrecognized pathology occurring in soft tissue. The internal margin of the tendo patellae was measured from its origin just above the tibial tubercle to the nearest point of the patella. To further check this measurement we measured the distance between the nearest tibial and patellar points.

Variations in the length of the tendon should correspond to age during the growth period, twenty years, after which one would not expect age to affect this structure. The effect of height upon this tendon is not discussed in this paper, because its importance did not occur to us until we began to investigate the matter.

The following table summarizes our findings.

TABLE I

Age	Average Length of Tendo Patellae	Shortest Length	No. of Cases
5–10 years	4.82 cm.	2.80 cm.	4
11–20 years	4.79 cm.	2.77 cm.	27
21–30 years	4.81 cm.	2.78 cm.	19
31–40 years	4.97 cm.	2.74 cm.	16
41–50 years	5.10 cm.	2.75 cm.	12
51–60 years	5.32 cm.	2.81 cm.	8
61–70 years	4.36 cm.	2.57 cm.	8
71–80 years	5.31 cm.	2.51 cm.	6

We can neglect the five-to-ten-year period because of the few cases; in fact the sparsity of cases is regrettable throughout the entire series. One cannot draw hard, fixed rules from one hundred cases; if we had one thousand cases, evenly distributed in age groups, we could be more definite in our statements.

Beginning with the second age group—low limit eleven years—and progressing to the high limit of the sixth age group, the true patellar-tendon measurement increases definitely. The explanation is not difficult. Histologically the tendon is composed of yellow and white elastic tissue, and we should have been able to predict this finding.

At sixty years of age, the factor of hypertrophic arthritic changes arises: the elastic tissue loses its elasticity, and bony outgrowths shorten the measurements. This is more especially noted in the short measurement as the articular cartilage thins with age, permitting the patella to approach the osseous structures.

The figures presented represent averages, but it would be advantageous to know the extremes as well as the means:

The shortest true tendon measured 3.0 cm.
The longest true tendon measured 6.8 cm.
The shortest short measurement was 1.9 cm.
The longest short measurement was 4.1 cm.

We can safely say that any tendo patellae measuring over six and five-tenths centimeters should be regarded with suspicion and carefully examined for continuity of structure.

In our case of bilaterally ruptured tendo patellae the tendon measurement was eight centimeters right, and eight and one-tenth centimeters left, and—of greater importance—the shredded ends of the tendons were visualized. Occasionally the upper end of the tibia deviates from the normal conformation; for this reason we use the short tibial-patellar measurement. In case rupture is suspected, the two measurements should be correspondingly increased; whereas in a deviation from the normal the short measurement will not check.

CONCLUSIONS

We have measured the length of the patellar tendon in a small number of cases, using normal lateral roentgenograms.

A gradual increase in the length of the tendon after the close of the growth period is noted. This is assumed to be due to stretching of elastic connective tissue.

A table with the derived normal lengths is presented.

We feel that in some large center further studies on a larger series of cases should be made.

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A STUDY OF THE BLOOD SUPPLY OF THE LIGAMENTUM TERES AND ITS RELATION TO THE CIRCULATION OF THE HEAD OF THE FEMUR *

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The ligamentum teres has been known since ancient times. Singer states that Hegetor, one of the later Alexandrian medical writers who lived about 130 B.C., recognized the round ligament of the hip joint. The controversy regarding the vascularity of the ligament did not begin until after Paletta's original statement in 1820. Paletta wrote in Latin, which is not available to us. Moser (1892) translated Paletta's statement as follows: "The obturator artery gives off a small branch which passes through the acetabular fossa and divides into two branches,—one for the fossa and one which traverses the round ligament to supply the head of the femur." Since that time the literature has been quite contradictory.

Only a few of the more important papers will be discussed, since Moser (1892), Kolodny (1925), Phemister (1931), and others have published reviews. Hyrtl (1846) declared that the ligamentum teres did not carry nutrient vessels, since injection experiments demonstrated that the vessels in the ligament anastomosed with veins at the junction of the ligament with the head and then passed back through the ligament. In contrast to this view, von Luschka (1865) very definitely states that he never failed to find arteries which made their way through the pores of the fovea capitis into the substance of the head of the femur. No mention is made of the number of specimens examined. Von Luschka also recognized that arteries pass along the synovial membrane and penetrate the bone near the cartilaginous junction. Welcker (1876) investigated the problem by observing the fovea capitis for the presence of pores. He does not state the number of cases examined, but found that in one-third there were no pores, and in the remainder the openings were so small as to be negligible. Welcker also examined children and young adults and found that the openings were either absent or very small. Langer (1878) studied the vascularity of the ligamentum teres by the injection method. In this way he demonstrated an artery in the ligament which passes into the cartilaginous head, and in addition a supply arising from the epiphyseal arteries. An anastomosis occurs between the two systems as soon as the bony nucleus arises. In older children Langer states that injection of the obturator artery proves that the round ligament serves as a conduit by which vessels pass to the

* Presented before the Chicago Surgical Society, April 1, 1932.

head of the femur. Langer fails to state the number of cases observed, but records the following general conclusions: examples in which there are as many as four one-millimeter-sized openings in the fovea capitis, some ligaments which contain no vessels or a number of small vessels, and still other specimens in which the ligament is entirely wanting.

Moser (1892) made serial sections of the ligament and the head of the femur in many stages of foetal life and childhood up to four years. When the ligament first appears it is avascular; but in embryos twelve centimeters long, vessels pass into the head. By the seventh foetal month three to four branches are present in the ligament. Moser considers this supply of much less importance than that which reaches the head through the synovial membrane surrounding the neck of the femur. He further states that he could not be sure that the vessels contained in the ligament were necessary for the ossification of the head. Moser did not carry his studies beyond the fourth year of child life, because he believed that the ligament becomes atrophic at about this age, due to the unfavorable environment in which the ligament finds itself during active life. Moser also examined the fovea capitis for foramina. They were present in about one-half of the cases examined and doubt is expressed as to whether these actually ever contained blood vessels. This fact, plus the delayed appearance, indicates that the ligament is wholly non-essential at all ages and certainly in adult life.

Walmsley (1915) studied the vascularity of the ligamentum teres by two methods. By the use of a hand lens, one hundred ligaments were examined without finding vessels. Whether these bodies were injected or not is not stated. Walmsley observed that many vessels reach the head from the articular margin but none from the ligament. A second method of investigation was to inject the hypogastric arteries and the remainder of the general circulation with different colored solutions. This was carried out in specimens from two children,—one, two and the other, six years old. In both cases the injected material which filled the head came entirely from the vessels entering at the articular margin of the head. A small area of cartilage in the immediate proximity of the attachment of the ligamentum teres seemed to be vascularized. "These results", says Walmsley, "show that the ligament does not convey blood to the head of the femur. Most of the foramina in the fovea capitis are channels of communications of the ligamentous tissue into the cartilage and osseous substance of the bone."

Many clinicians have contributed to the anatomical knowledge regarding the ligamentum teres. A few of these contributors have been Phemister, Kolodny, Santos, and Schmorl. Probably most clinicians feel that the ligamentum teres is of little importance either as a ligament or as a source of nutrition to the head and neck of the femur. The following statement from Jones and Lovett's 1929 edition of Orthopedic Surgery probably summarizes the current view: "The ligamentum teres is intra-articular, apparently concerned in strengthening the joint and 'probably vestigial

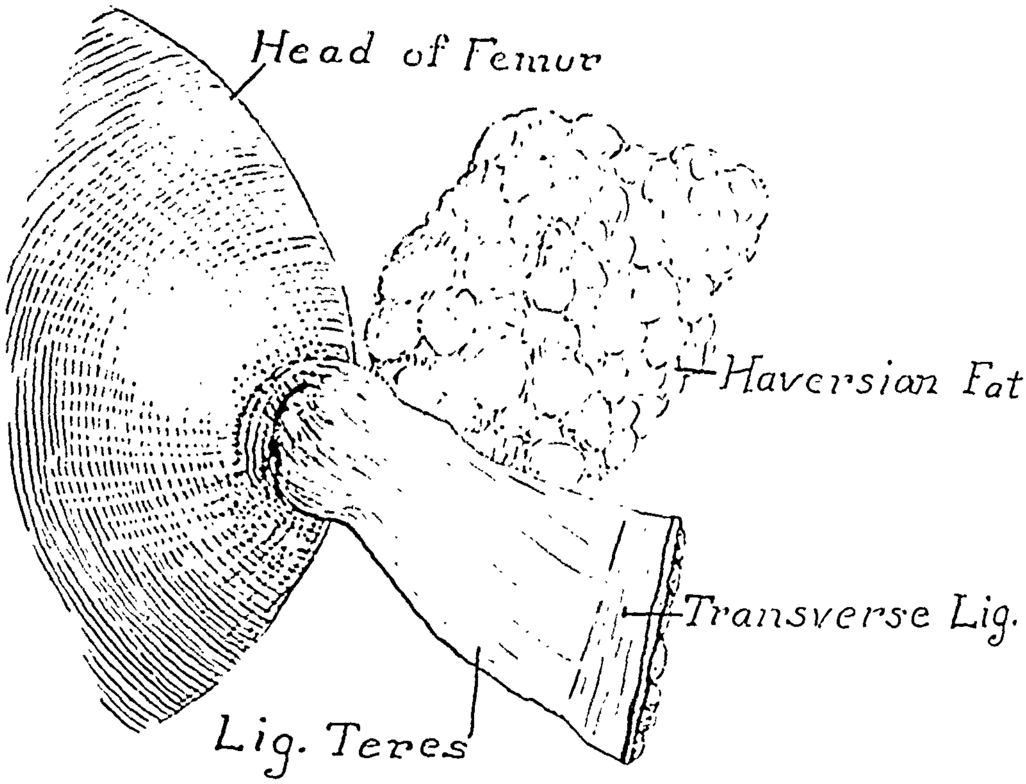

FIG. 1

A general view of the ligamentum teres. The haversian fat is attached to the dorsal surface of the ligament rather close to the head of the femur.

and practically useless'. It has been conclusively shown that the few vessels present in early life supply a small zone of articular cartilage only. In the adult the ligament is an avascular structure."

ANATOMICAL STUDY

The ligaments used in this study were removed from cadavera in the gross anatomy laboratory of Loyola University School of Medicine. The capsule of the hip joint was opened widely on the ventral, medial, and lateral aspects. The head of the femur was then slightly elevated from the joint so as to expose the ligamentum teres. The transverse ligament was then cut at both ends and the haversian fat removed from the non-articular portion of the acetabulum. The next procedure was to saw through the head of the femur and place all the tissue removed in ten per cent. formalin.

The gross appearance varied a great deal in different specimens. Excluding a few specimens in which gross pathology had taken place, and a few others where the embalming process had not been complete, all ligamenta teres removed appeared to be strong supporting structures. It is seldom round, but rather a flat band. The attachments are found to agree quite closely with that given in Cunningham's Text-Book of Anatomy. The distal attachment is into the superior one-half of the fovea capitis of the femur. The proximal insertion may be into the transverse ligament with some extensions into the lips of the acetabular notch. Records show

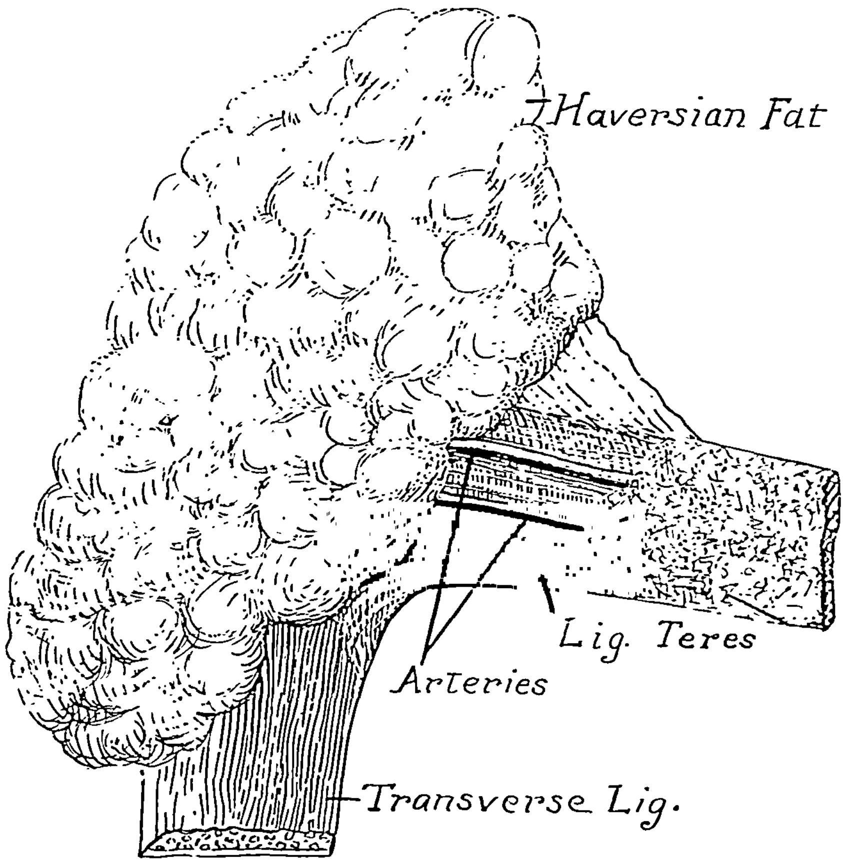

FIG. 2

A dorsal view of the transverse and teres ligaments, both partly covered by the haversian fat. Two macroscopic vessels pass to the femur along this surface of the round ligament.

that it is more commonly attached to the inferior lip and to a portion of the transverse ligament. The attachment may be into the inferior ischial lip of the notch alone.

All ligaments were removed from sixty-eight adult cadavera, the average age at death being forty-eight years. Measurements were made after hardening in formalin for a few days. The length of the fixed ligament was about two and five-tenths centimeters long and one to one and five-tenths centimeters wide and almost invariably three to four millimeters thick. In some cases the haversian fat was attached to the dorsal surface of the whole of the ligament, so that some measurements are approximations. Even when the haversian fat was attached more proximally, fat might extend all along the dorsal surface down to the fovea capitis. In one case the ligament did not appear to be anything but a fold of synovial membrane passing from the haversian fat to the fovea capitis. A macroscopic vessel was present, however. When sectioned, this structure was composed of ligamentous tissue (Figs. 3 and 4).

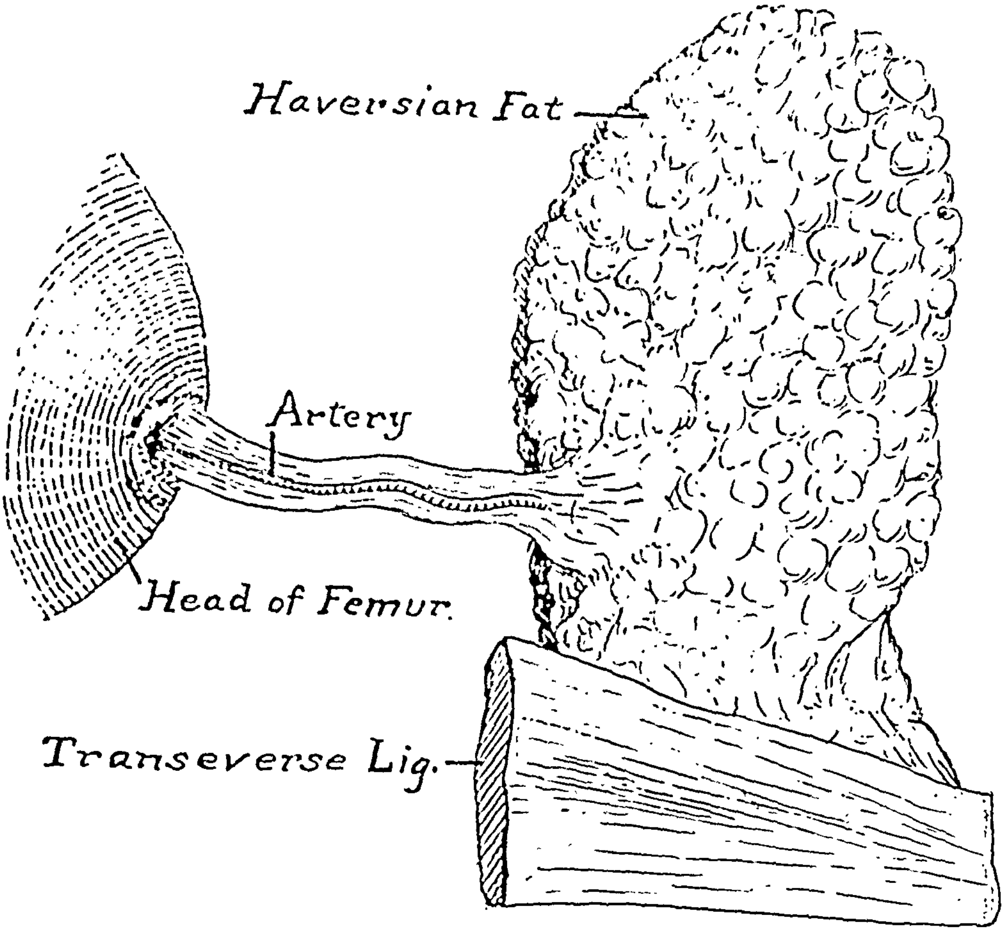

FIG. 3

The only atrophic ligament encountered. A macroscopic vessel passes from the haversian fat into the femoral head.

The histological preparations were made near the junction of the ligament with the femur. *All ligaments contained vessels,* but there was considerable variation in the number of vessels found. The observations support and extend those made by von Luschka and Langer.

The following table shows the size of the vessels and the number of ligaments in each group:

VASCULARITY OF 114 LIGAMENTA TERES IN MAN

Number of Ligaments	*Size of Vessels*
4	Relatively avascular
8	Many small vessels
16	Sclerosed, partially or wholly obliterating lumen
36	.2 to .4 m.m. in diameter
50	.4 to 1.5 m.m. in diameter

All measurements were made by the aid of an ocular micrometer and camera lucida drawings. The distribution of the vessels is not at all constant. Vessels may be on the dorsal surface or near the center of the ligament. They may be surrounded by loose areolar connective tissue and fat, or found coursing between heavy bundles of ligamentous tissue.

CLINICAL DISCUSSION

Observations were made on three fractures in cadavera. In all three instances the fracture had been complete, so that the only nourishment to the proximal fragment was through the ligamentum teres. In the first case, the gross and microscopic appearance was greatly distorted by a very extensive inflammation. Many newly formed vessels were present. In the second case, the fracture had existed about three months. The fragments were in apposition and held together by loose adhesions. The ligamentum teres contained a macroscopic-sized vessel and some injected material. In the third case, the patient lived about three years after the fracture. The largest vessel in this ligament was about one and five-tenths millimeters in diameter. A fibrous union had taken place. Serial sections of the ligament and the head of the femur showed that the vessel divided into smaller branches as soon as it penetrated the substance of the bone (Fig. 11).

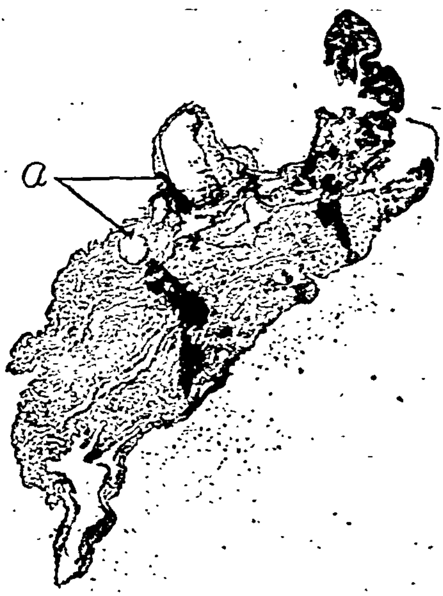

FIG. 4

A photomicrograph of the ligament shown in Fig 3. Bundles of ligamentous tissue are present. Several fair-sized vessels (a) shown peripherally. (×9.)

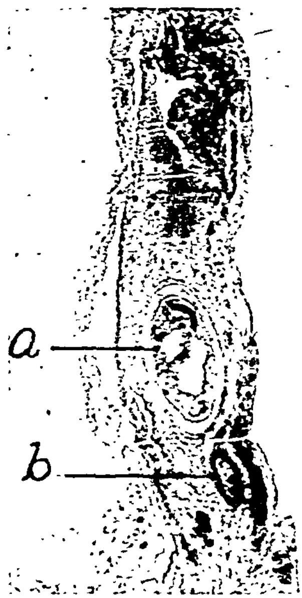

FIG. 5

The ligamentum teres and the vessels contained therein. The largest vessel (a) is 1.3 m.m. as measured on the slide. A smaller independent vessel is shown (b). (×9.)

Schmorl (1924) reports a similar case of complete fracture of the neck, including the vessels in the synovial membrane, but union occurred because of the blood supply through the ligamentum teres.

A more detailed histological study was made from serial sections of the ligaments and a portion of the head of the femur in six specimens, including two of the fracture cases (Figs. 8, 9, 10, 11). These all show con-

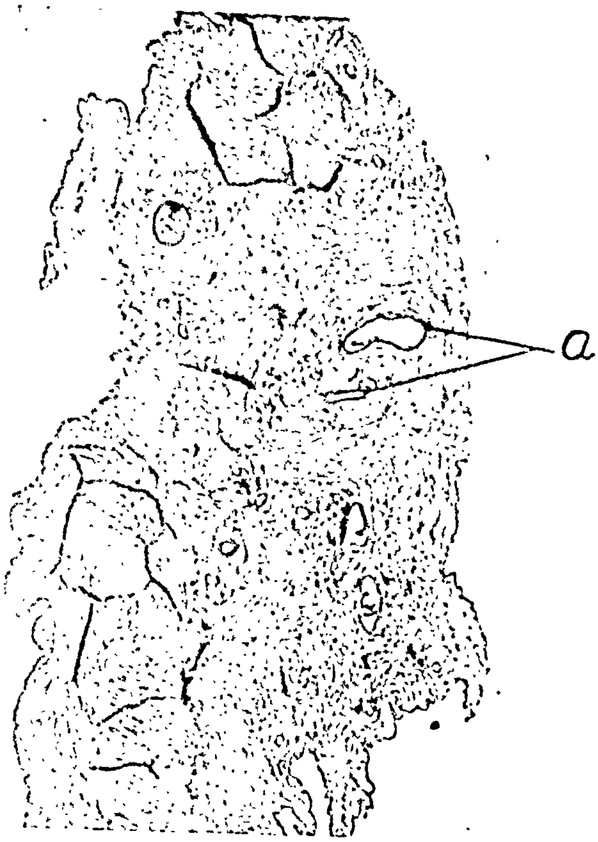

FIG. 6

Cross-section view of the ligamentum teres, showing a vessel surrounded by an area of fat and loose areolar connective tissue (*a*), also numerous smaller vessels.

FIG. 7

A relatively avascular ligamentum teres. Only precapillary vessels were observed in this specimen. (×9.)

clusively that the vessels of the ligament divide in the substance of the head of the femur to nourish the bone.

The information gained from this anatomical and histological study has a very definite clinical application. From the careful examination of 114 ligaments taken from adult human cadavera, ranging in ages at death from twenty-five to seventy-five years, it is shown that in many instances there are vessels varying from very small arteries to those measuring one and five-tenths millimeters in diameter. The larger vessels were found in the older, as well as in the younger, cases. This was true also of those in which there were a number of vessels. Those vessels showing sclerosis were practically all in older subjects. It is assumed that in these cases there was present a generalized arteriosclerosis. It was, furthermore, shown from the serial sections that vessels penetrated the head of the femur in cases of varying ages.

In operations for congenital dislocations of the hip in the young, it has been observed that in some cases, at least, there were only small macroscopic vessels in the small stretched-out ligaments in those cases where the x-ray films show infantile femoral heads. Fairly large vessels were found in the ligaments in some cases where the head, even though out

of the acetabulum, was of fair size and shape. None of these ligaments were, for obvious reasons, submitted to cross section and study.

It is not our conclusion from this study and from clinical observation that the entire proximal portion of the femoral head is dependent upon the blood supply coming through the ligamentum teres. We believe with Schmorl that, when the vessels and periosteum surrounding the neck of the femur are completely torn or loosened, non-union of the head to the neck often occurs. It is entirely possible, however, that in severe injury to the head and neck, as occurs in fractures and dislocations, the vessels in the ligament may, by direct tear or torsion, have been obliterated.

We believe that the arterial supply through the ligament is of so much importance that great care should be exercised in all hip operations. A large hole drilled through the head of the femur may easily extend into the fovea and destroy the ligamentous attachment, as occurred in one of our cases. The operation was done ten months after the fracture; the head seemed normal as to circulation; the capsular attachment

Fig. 8

The ligamentum teres from Case 3 of the fracture series. Very large artery shown partially collapsed.

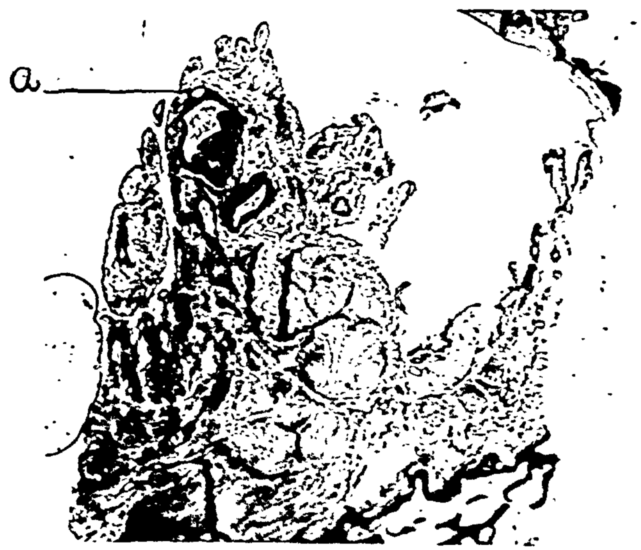

Fig. 9

Same as Fig. 8 except at the junction of the ligament with the fovea capitis. The small artery (a) is a branch of the larger one.

Fig. 10

One of the serial sections through the fovea capitis. Artery marked *a* is passing between the bone trabeculae (*b*) into the head of the femur. Outline of fovea capitis (*F. C.*) is indicated by heavy line.

Fig. 11

Three sections beyond that shown in Fig. 10. The artery in Fig. 10 has now divided into two branches (*a*) in the head of the femur. Fovea capitis indicated by heavy line (*F. C.*).

FIG. 12

Mrs. R., December 17, 1928. Non-union shown ten months after fracture.

FIG. 13

Mrs. R., April 9, 1930. Union of fracture thirteen months after bone graft. Bone graft extends directly into fovea. Very little weight-bearing had been permitted to this time.

FIG. 14

Mrs. R., May 1, 1932. Same case as shown in Figs. 12 and 13, thirty-seven months after operation. Blood supply from ligamentum teres having been destroyed by large bone drill opening into fovea, the head has collapsed and has assumed a triangular shape with apex of triangle at fovea.

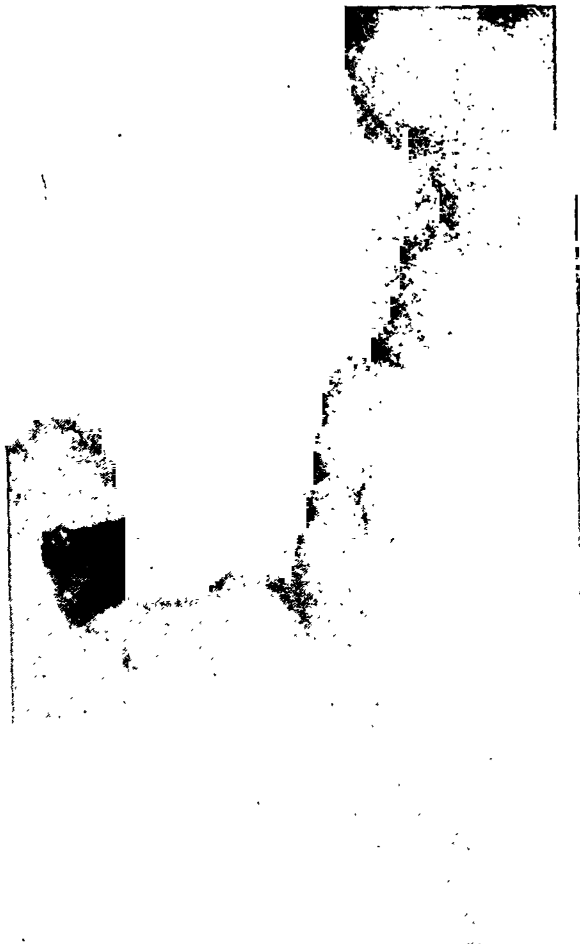

FIG. 15

Central dislocation without fragmentation of head of femur. No fracture of the neck was observed.

FIG. 16

Necrosis six months after accident, such as seen in Perthes' disease, is confined to that area immediately surrounding the fovea. Note penetration of process toward neck, only slightly laterally.

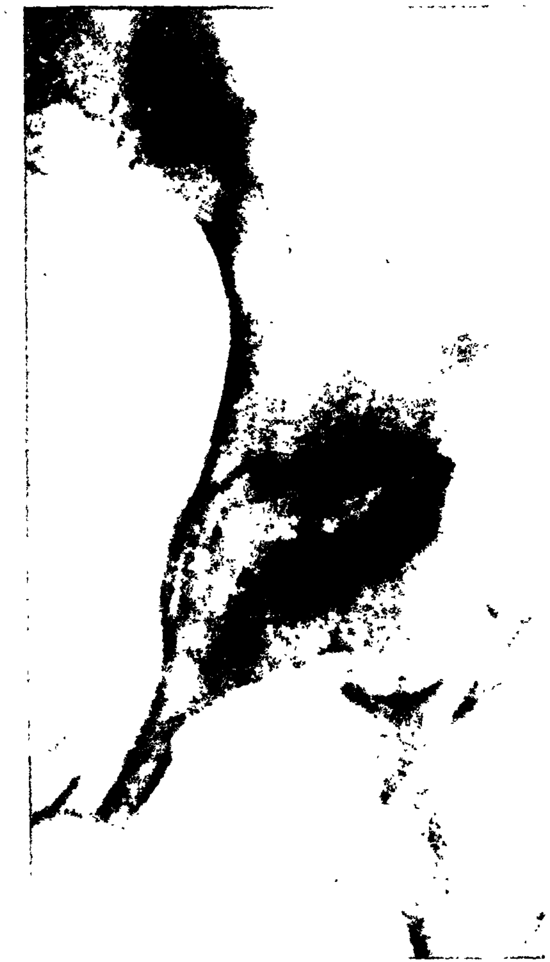

FIG. 17

Ten years after accident. Greatest destruction has taken place in central cone of head.

and the vessels about the neck were not disturbed. Several months after operation some atrophy was observed in the head. Marked absorption is now shown three years after the bone-graft operation (Figs. 12, 13, 14).

Traumatic dislocation of the hip often completely severs the ligament and cases have been reported where flattening of the head occurs. A girl, aged fourteen, sustained a central dislocation of the femoral head (Fig. 15). Immediate replacement of the head was done by the closed method. There was no fragmentation of the head nor was there a fracture of the neck. Six months later the patient returned to the hospital because of slight pain in the hip with some muscular fixation. The x-ray film showed a definite necrosis in the region of the fovea (Fig. 16). The appearance was not unlike that of Perthes' disease, except that the aseptic necrosis was confined so definitely to the region where the ligament attaches. The process of necrosis seemed to extend from the fovea directly into the head and only slightly laterally. Films made at frequent intervals showed that the destruction had ceased after invading that portion which we have reason to believe is supplied by the arteries of the ligament, as shown in the most recent examination, ten years after the accident (Fig. 17). This might well be diagnosed as a destruction of the ligament, Perthes' type, with an absence of blood supply of the ligamentum teres as the etiological factor. There is, however, in this case more marked limitation of motion at the hip than we usually find. Flexion is limited to a right angle; extension is almost entirely absent; and rotation is limited to several degrees, showing that the entire head has undergone a change in size and conformation. In all operative procedures upon the hip, a careful manipulation of the head of the femur is imperative. Most careful handling, according to the method of Smith-Petersen, or some similar method, is to be recommended.

We should hesitate to remove the head from the acetabulum for the purpose of pegging it to the neck with beef bone or steel screw as reported in some recent articles [3, 4].

SUMMARY

Observation on 114 ligamenta teres of the hip joint in man justify the following conclusions:

1. A true ligament was present in every instance except one.
2. All ligaments contained vessels. In four cases the vessels were of precapillary size. All other ligaments contained a significant blood supply.
3. Serial sections of the junction of the ligament with the femur demonstrate an anastomosis between the vessels in the ligament and those of the head of the femur.
4. This anatomical study supplemented by clinical experience strongly supports the conviction that the ligamentum teres and its circulation should not be disturbed in any operative procedure.

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A SURVEY OF THE TREATMENT OF TUBERCULOSIS OF THE KNEE JOINT

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In this article an attempt will be made to put forward a rational method of treating cases of tuberculosis of the knee joint. Despite the large amount of work that has been and is being done on the subject, a study of the literature shows that no unanimity has been reached in connection with the important problems involved in such treatment; and it will be for this reason my secondary aim to suggest a possible explanation for the prevailing disharmony of opinion.

The following quotations from the works of recognized authorities show sufficiently how little agreement has so far been attained on this subject:

"In childhood, under favorable conditions, ultimate recovery, with fair functional use of the joint, may be anticipated; while a radical operation, although it may cure the patient in a shorter time, takes away the possibility of a cure with motion. . . . in childhood, the removal of portions of the epiphyses and of the epiphyseal cartilages entails a progressive inequality in the limbs, due to loss of growth; furthermore, unless the limb is protected by mechanical means, deformity is the rule, even though the disease has been thoroughly removed." [1]

Results obtained by medical treatment only at the New York Orthopaedic Hospital, as reported by Dr. Whitman, showed:

- Thirty-seven per cent. with movement at the knee from 180 degrees to 90 degrees.
- Thirty-four per cent. with movement from 180 degrees to between 90 degrees and 165 degrees.
- Twelve per cent. with ankylosis in extension.
- Twelve per cent. with ankylosis in flexion.
- Five per cent. with flexion deformity without ankylosis.[2]

Results obtained by arthrodesis at two different clinics, as quoted by Dr. Whitman, were:

- Twenty-seven per cent. with the knee fixed in extension.
- Twenty-eight per cent. with the knee fixed in moderate flexion.
- Forty-five per cent. with the knee fixed in marked flexion.[3]

and:

- Ninety-one per cent. with the knee fixed in extension.
- Nine per cent. with the knee fixed with deformity.[4]

Fraser calls attention to the fact that "the infection is more frequently in the synovial membrane than in the bone". He states: "If the case comes under appropriate care sufficiently early, one can usually guarantee a complete cure. In certain of these cases the movement

of the joint will be perfect in every respect; in the majority, while there is healing of the actual disease, the movements may be limited through varying degrees . . . in young children, if there is a likelihood of operation becoming necessary, such ought not to be delayed too long."[5]

"The philosopher would look upon it as a dispensation of providence that it is in the knee joint, where our conservative treatment most frequently suffers shipwreck, that operative treatment has achieved its most brilliant results."[6]

"Tuberculosis of the knee joint becomes manifest in the majority of cases only as a synovitis. . . . Generally speaking the tendency to recover is greater in bone lesions than in tuberculous synovitis."[7]

The site of primary incidence, as discovered by opening the knee joint, is shown by two different clinics to be:

Ninety-three per cent. in the synovial membrane.
Seven per cent. in the bones about the joint.[8]

and:

Forty-nine per cent. in the synovial membrane.
Fifty-one per cent. in the bones about the joint.[9]

The site of primary incidence shown by dissecting adult amputation stumps was:

Forty-one per cent. in the synovial membrane.
Fifty-nine per cent. in the bones about the joint.[10]

Such a diversity of opinions on the factors governing prognosis and treatment seemed to me to justify a fresh investigation. It was decided, accordingly, to follow up the cases treated by the orthopaedic department of Saint Thomas's Hospital and at the orthopaedic hospitals for children at Pyrford. The series consisted, then, of all the cases treated between the years 1920 and 1930 of which records were available.

To eliminate any confusion that might arise from possible errors in diagnosis, it was decided to consider separately those cases in which absolute proof of tuberculosis was obtainable and those in which the diagnosis was not beyond dispute. Two proofs only were accepted as conclusive evidence of tuberculous infection: either a record that the typical microscopic appearance of tuberculosis was seen, or that tubercle bacilli had been demonstrated in the caseous material from the joint or the cavity in the bone. My method of deciding whether the primary lesion was in bone or synovial membrane was simple but perhaps open to criticism. In all those cases in which the skiagram showed local (as opposed to general) rarefaction of bone the presence of a primary osseous focus was assumed, while in the others the primary focus was assumed to be in the synovial membrane. The great difference in prognosis in the two groups, as shown by the data to be presented in this article, affords ample justification for this way of distinguishing between them; moreover, it seems the only method available in those cases in which the interior of the joint has not been inspected.

ANALYSIS OF CASES CONSTITUTING THE SERIES

The series under discussion includes seventy-eight cases treated between the years 1920 and 1930. In the following analysis each will be given its serial number as it appears in the total group, and it should be realized that many of the cases are referred to under more than one heading, illustrating, as they do, different points that it was desired to bring out.

In the following sixteen cases the presence of tuberculous disease was confirmed by applying the criteria previously mentioned,—namely, either there was microscopic evidence of tuberculosis in a piece of excised synovial membrane or tubercle bacilli were demonstrated in pus from the joint.

SYNOVIAL TUBERCULOSIS

Proven Cases

Case 13. Immobilized for 5 years; arthrodesis; bony union in ¾ year.
Case 14. Immobilized for 3¼ years: result, still active: still in a caliper.
Case 18. Immobilized for 2¼ years: result, walking without caliper, range 30 degrees.
Case 29. Immobilized for 2½ years; arthrodesis; still in plaster 1 year later.
Case 30. Immobilized for ½ year; arthrodesis; bony union in 1¾ years.
Case 36. Immobilized for 2 years: result, still in a caliper.
Case 39. Immobilized for 3 years; result, range 5 degrees.
Case 40. Immobilized for ¾ year; result, range 175 degrees to 100 degrees and increasing.
Case 54. Immobilized for 2 years: arthrodesis; bony union progressing well ½ year later.
Case 56 Immediate arthrodesis; result, still in a splint 1½ years later.
Case 60. Immediate arthrodesis; result, bony union in 2¼ years.
Case 66. Immediate arthrodesis; result, bony union in 1 year.
Case 67. Immediate arthrodesis; result, bony union in ¾ year.
Case 68. Immediate arthrodesis; result, bony union in 1 year.
Case 69. Immediate arthrodesis; amputated 4 months later because of sepsis.
Case 74. Immediate arthrodesis: result, bony union in 1 year.

Unproven Cases

The group diagnosed clinically as synovial tuberculosis, but not proved to have been so, has been divided for convenience into: (a) those which were treated by immobilization only; (b) those in which immobilization was followed by arthrodesis; (c) those which were treated by arthrodesis without previous immobilization.

(*a*). *Treated by immobilization only*

Case 2. Immobilized for 2¾ years: result, still in a caliper.
Case 3. Immobilized for 10 years: result, full range.
Case 5. Immobilized for 2¾ years: result, slight limitation of flexion.
Case 6. Immobilized for 4½ years: result, unsound ankylosis in extension.
Case 7. Immobilized for 6 years: result, range 175 degrees to 150 degrees.
Case 9. Immobilized for 3½ years: result, still in a caliper, range 165 degrees to 160 degrees.

Case 10. Immobilized for 3½ years; result, range 180 degrees to 175 degrees.
Case 11. Immobilized for 5 years; result, range 175 degrees to 120 degrees.
Case 16. Immobilized for 3¾ years; result, range 175 degrees to 90 degrees.
Case 17. Immobilized for 6½ years; result, not known.
Case 19. Immobilized for 3½ years; result, full range.
Case 21. Immobilized for 6¼ years; result, fixed in extension, still in a caliper.
Case 24. Immobilized for 4½ years; result, fixed in extension.
Case 26. Immobilized for 1 year; result, still in a caliper.
Case 27. Immobilized for 1½ years; result, full range.
Case 31. Immobilized for 13 years; result, unsound ankylosis, flexing in caliper.
Case 32. Immobilized for 1 year; result, range 180 degrees to 170 degrees. Died 3 months later of tuberculous meningitis.
Case 33. Immobilized for 3 years; result, still in a caliper.
Case 41. Immobilized for 7 years; result, still in a caliper.
Case 42. Immobilized for 2¾ years; result, range 180 degrees to 90 degrees.
Case 43. Immobilized for 6 years; result, unsound ankylosis in 30 degrees' flexion.
Case 44. Immobilized for 7 years; result, fixed in extension.
Case 46 Immobilized for 14¼ years; result, fixed in extension.
Case 48. Immobilized for 5½ years; result, range 190 degrees to 60 degrees.
Case 51. Immobilized for ¾ year; result, full range.
Case 57. Immobilized for 3 years; just begun to get up in caliper.
Case 70. Immobilized for 3 years; result, full range.
Case 71. Immobilized for 2 years; result, full range.
Case 73. Immobilized for 2 years; result, full range.

(*b*). *Treated by immobilization followed by arthrodesis*

Case 1. Immobilized for 7 years; bony union in 1½ years.
Case 4. Immobilized for 6¾ years; bony union in 1 year.
Case 15. Immobilized for 4 years; bony union in 1 year.
Case 37. Immobilized for 2½ years; bony union in 3½ years.
Case 38. Immobilized for 5¼ years; bony union in 5½ years.
Case 50. Immobilized for 1½ years; bony union in ½ year.
Case 59. Immobilized for 7 years; bony union in 1¼ years.
Case 61. Immobilized for 2¾ years; bony union in ½ year.
Case 65. Immobilized for 1¼ years; bony union in 2¾ years.
Case 77. Immobilized for 4 years; bony union in ½ year.

(*c*). *Treated by arthrodesis without preliminary immobilization*

Case 20. Arthrodesis; result unknown.
Case 52. Arthrodesis; died a month later of tuberculous bronchopneumonia.
Case 53. Arthrodesis; bony union in ½ year.
Case 55. Two arthrodeses; bony union in 10 years from the date of the second operation.
Case 58. Arthrodesis; bony union in 3 years.
Case 63. Arthrodesis; result unknown.
Case 64. Arthrodesis; bony union in ½ year.
Case 72. Arthrodesis; bony union in 1¼ years.

OSSEOUS TUBERCULOSIS

Proven Cases

In the following five cases the presence of tuberculosis was confined by applying the criteria already set forth:

Case 8. Immobilized for 2¾ years; two sequestrectomies during that time; result, range 175 degrees to 45 degrees.
Case 22. Immobilized for 3 years; two sequestrectomies during that time; result, full range.
Case 45. Immobilized for 4¾ years; abscess opened during that time; result, fixed in extension.
Case 62. Immobilized for 2 years; result, full range. Died later of tuberculous meningitis.
Case 76. Immobilized for ½ year; abscess opened; result, still in a caliper.

Unproven Cases

In the following five cases the clinical condition of the joint suggested tuberculous disease, but the diagnosis was not confirmed. That the diagnosis was none the less correct is suggested by the fact that two patients in this group died of tuberculous meningitis.

Case 23. Immobilized for 2 years; result, fixed in extension. Died later of tuberculous meningitis.
Case 28. Immobilized for 2½ years; result, range 180 degrees to 130 degrees.
Case 34. Immobilized for 2 years; result, full range.
Case 35. Immobilized for 4 years; result unknown.
Case 47. Immobilized for 4 years; result, fixed in extension. Died later of tuberculous meningitis.

NON-TUBERCULOUS CASES

This group, to which I wish to draw special attention, includes those cases in which, despite a clinical diagnosis of tuberculosis and observation for varying lengths of time, synovectomy followed by microscopic examination showed no evidence that such disease had in fact been present.

In the series of seventy-eight cases, diagnostic synovectomy was carried out twenty-six times and on five occasions suggested that the diagnosis was wrong. The results of treatment in these five cases differ so markedly from those of the other cases in the series as to corroborate the absence of tuberculosis found at microscopy, which in each case disclosed a non-specific chronic inflammation of the synovial membrane. In view of the theory that in these non-tuberculous cases simulating tuberculosis the cause of the condition is an unsuspected syphilitic infection, it has been thought worth while to record the result of the Wassermann reaction in the two cases in which it was obtained.

CASE 12. The knee joint of this patient, aged four years, was immobilized for eight months and then opened and drained on account of sepsis. Lack of improvement after three months necessitated amputation above the knee.

CASE 25. The knee joint of this patient, aged eight years, was immobilized for four years and then a synovectomy showed the absence of tuberculosis. One year later the range of movement was 178 degrees to 45 degrees; the joint creaked. The Wassermann reaction was negative.

CASE 49. Tuberculosis of the knee joint was diagnosed when this patient was five years old, and, after two years of immobilization, the knee was said to be normal. The patient came under observation again, at the age of twenty-one, with a history of recent

trauma to the joint. In view of the history and of the clinical signs, a diagnosis of tuberculosis was made. Arthrodesis was carried out at once but subsequent microscopy showed evidence of non-tuberculous infection only.

CASE 75. In this patient, aged nine and three-quarters years, a clinical diagnosis of tuberculosis of the knee joint was made. The Wassermann reaction was negative. Synovectomy was carried out forthwith and no evidence of tuberculosis was found. Five months later the knee appeared normal.

CASE 78. The knee joint of this patient, aged four and one-fourth years, was immobilized for two and one-half years following a diagnosis of tuberculosis. At the end of this time, the range of movement at the knee joint was 180 degrees to 60 degrees. In view of the fact that full range of movement was never attained, in spite of full use of the joint, synovectomy was carried out one and one-half years later: again evidence of non-tuberculous infection was found. Two-and-a-half years later the range of movement was 175 degrees to 95 degrees, and creaking was marked.

PROGNOSTIC SIGNIFICANCE OF PATIENT'S AGE

With a view to discovering what relation, if any, exists between the age of the patient when arthrodesis is carried out and the time taken to achieve bony union, the following analysis has been made, recording the age of the patient and the time taken to achieve bony union.

Case Number	Age at Arthrodesis (*Years*)	Time Taken to Achieve Bony Union (*Years*)	Case Number	Age at Arthrodesis (*Years*)	Time Taken to Achieve Bony Union (*Years*)
1	14	1½	56	19	1½+
4	13	1	58	58	3
13	10¾	¾	59	9¼	1¼
15	13¾	1	60	30	2¼
20	15	Result unknown	61	22	¾
29	14	1+	63	28	Result unknown
30	14¾	1¾	64	22½	½
37	15½	3½	65	11¼	2¾
38	6	5½	66	18¼	1
49	21	1½	67	21	¾
50	17	½	68	28	1
52	43	died	69	59	Amputation
53	28	½	72	39	1¼
54	16½	Result unknown	74	22	1¼
55	2	13	77	22	½

More shortly the above cases may be classified in the following age groups:

Age Group (*Years*)	Average Time Taken to Achieve Bony Union (*Years*)	Age Group (*Years*)	Average Time Taken to Achieve Bony Union (*Years*)
2 to 6	9¼	15 to 20	1½
9 to 12	1½	20 to 30	1
12 to 15	1¼	39 to 60	2

In only one patient under fifteen years of age,—namely, Case 55—was arthrodesis performed without previous immobilization.

Less than half the patients between fifteen and thirty years of age were treated by previous immobilization.

EFFECT ON BONY UNION OF PREVIOUS IMMOBILIZATION

With a view to discovering what relation, if any, irrespective of the age of the patient, exists between the duration of immobilization and the time taken after arthrodesis to achieve bony union, the following analysis was made:

Case Number	Duration of Immobilization (*Years*)	Time Taken to Achieve Bony Union (*Years*)	Age at Arthrodesis (*Years*)
1	7	1½	14
4	6¾	1	13
13	5	¾	10¾
15	4	1	15¾
29	2½	1+	14
30	½	1¾	14¾
37	2½	3½	15½
38	5¼	5½	6
50	1½	½	17
54	2	½+	16½
59	7	1¼	9¼
61	2¾	½	22
65	1¼	2¾	11¼
77	4	½	22

The lack of any discernible correlation between the length of treatment by immobilization and the time taken to achieve bony union seems to corroborate the finding of the previous analysis,—*i. e.*, that the time taken to effect bony union can be correlated most usefully with the ages of the patients.

SUMMARY OF CASES DIAGNOSED AS HAVING A SYNOVIAL INFECTION

Of seventy-eight cases, sixty-eight were diagnosed as primary synovial infections, and in sixteen of these the diagnosis was proved.

Proven Cases

Cases treated by immobilization only

The following results were obtained after an average period of immobilization of two and one-half years: of nine patients, four had unstable ankyloses (and were subjected to arthrodesis): two were still in a caliper; one had 5 degrees', one 30 degrees', and one 75 degrees' range of movement.

Cases treated by immobilization followed by arthrodesis

The average age in this group of four patients was fourteen years. Arthrodesis was performed after an average period of immobilization of

two and one-half years. In all these, bony union without deformity was attained in an average period of one and one-fourth years.

Cases treated by arthrodesis only

The average age in this group of seven patients was twenty-three years. In six of these, bony union followed arthrodesis in an average period of one and one-fourth years. In one patient, aged fifty-nine, sepsis necessitated amputation of the leg four months after the arthrodesis.

Summary of Findings in Proven Group

In no case was immobilization followed by complete return of the joint to its normal condition, or even by ability to bend the knee to a right angle. Arthrodesis was successful in obtaining bony union without deformity in every case except the one in which amputation became necessary. No patient died.

Unproven Cases

In the following fifty-two cases the diagnosis was not proved.

Treated by immobilization only

In this group of thirty-nine patients, the following results were recorded:

In three, sound ankylosis was attained after an average period of eight and three-fourths years.

In two, an unsound ankylosis was attained after an average period of nine and one-half years.

In ten, an unsound ankylosis was also attained, but, after an average period of immobilization of four and one-fourth years, arthrodesis was performed.

In one, slight movement remained with marked flexion deformity.

In three, the range of movement attained was between 30 degrees and 60 degrees.

In two, the range of movement attained was from 180 degrees to 90 degrees.

In nine, calipers were still worn at the end of an average period of four and three-fourths years.

In one, death from tuberculous meningitis occurred one and one-fourth years after the beginning of treatment.

In eight, a full range of movement was attained after an average period of immobilization of three and one-fourth years.

Treated by immobilization followed by arthrodesis

In this group of ten patients, treatment by immobilization was persisted in for four and one-fourth years. Arthrodesis, performed at an average age of fourteen and one-fourth years, was followed by bony union in an average period of one and three-fourths years.

SUMMARY OF NON-TUBERCULOUS CASES

A diagnostic synovectomy was carried out in twenty-six cases, in five of which no evidence of tuberculosis was found. In two of the latter in which the *Wassermann reaction* was obtained, there was no evidence of syphilis. The average age in this group was six and one-half years and the average period of observation before synovectomy was two and one-fourth years.

In the five non-tuberculous patients, the following results were obtained:

In one, recovery was complete without treatment.

In one, recovery was complete after immobilization for two years.

In one, sepsis made amputation necessary.

In two, recovery was almost complete, leaving a condition similar to the osteo-arthritis of middle age.

CONCLUSIONS

1. Synovial tuberculosis was much commoner than osseous tuberculosis in the knee joint (in this series the proportion was sixty-eight to ten), and tended to occur at a later age.

2. In no proven case of synovial disease did the patient recover sufficiently to bend the knee to a right angle.

3. In no fewer than eight of forty-seven cases of unproven synovial disease was full range of the knee recovered.

4. Of twenty cases of synovial disease treated by immobilization for an average period of five years, in seventeen ankylosis was unsound enough to necessitate arthrodesis.

5. Arthrodesis produced bony union without deformity in all except two patients in whom it was undertaken; one of these died and the leg of the other had to be amputated. The average length of time for which immobilization was necessary after arthrodesis was one and one-fourth years in patients between the ages of nine and thirty. The arthrodeses were performed so as to fix the joint in full extension. Adequate protection of the limb was successful, even in children, in preventing subsequent deformity at the site of operation or at the epiphysis.

6. A careful examination of the skiagrams taken shortly after arthrodesis showed the epiphyseal lines (if present) to be intact in all cases. The distance of the epiphyseal cartilage from the end of the bone leaves the surgeon so much margin that such a result may reasonably be hoped for in synovial infection when the disease has not extended to the epiphyseal cartilage. Thus, following arthrodesis, there is no reason to expect shortening of the limb beyond that which is due to interference with growth by the tuberculous process.

7. The time taken to achieve bony union was independent of any variation in operative procedure. Furthermore, in patients of fifteen or over, it was unaffected by previous immobilization. In younger patients immobilization preceded arthrodesis in every case but one.

8. A comparison of the synovial and osseous groups with respect to mortality brings out the fact that, in the former group, two deaths occurred in sixty-eight cases; whereas, in the latter, three deaths occurred in ten cases.

9. In half the cases of osseous disease complete recovery resulted. It is probable, therefore, that, in cases in which the disease is not too advanced, the knee joint suffers only a so called sympathetic inflammation from which recovery may reasonably be expected whenever radical treatment can be directed to the focus in the bone without opening the knee joint itself. Moreover, only thus can the spread of tuberculous infection into the joint be prevented with any certainty.

10. In the cases proved to be non-tuberculous, the disease of the synovial membrane appeared either to recover completely, or to pass into a condition resembling the osteo-arthritis of middle age, or to get definitely worse with the development of sepsis.

These facts suggest the existence of a distinct disease of the synovial membrane of the knee joint, which lasts for years without affecting other joints. It is not syphilitic. It tends with treatment (or even without) in some cases to get completely well, in some to recover partly, with the development of a premature osteo-arthritis, and in some to become septic. In all these cases the synovial membrane showed the microscopic appearance of a non-specific chronic inflammation.

11. The fact that no proven case of synovial disease recovered suggests that the eight cases of unproven disease that did so may be regarded as: (a) wrongly diagnosed, or (b) primarily osseous cases in which the bony focus was too small to show on the skiagram.

Against the latter view is the fact that none of these cases proved fatal. And in favor of the former is the fact that, of twenty-six cases subjected to synovectomy, five showed no evidence of tuberculous infection. There is, therefore, nothing improbable in the hypothesis that there was an error of diagnosis in eight of the forty-two unproven cases.

RECOMMENDATIONS

1. Since it seems impossible, according to the data herein presented, to be sure of the diagnosis of tuberculosis of the knee joint, even in cases that have been observed for several years, it is suggested that diagnosis by synovectomy should be carried out on all patients over nine years of age (except in those in which the skiagram gives evidence of a bony focus) as soon as the diagnosis of a chronic arthritis is established. Under the age of nine, since treatment will be by immobilization in any event, a synovectomy is not indicated.

2. In view of the facts—that after immobilization for an average period of five years a clinically sound ankylosis resulted in only three of twenty cases in this series, that the evidence suggests that tuberculosis of the knee joint very seldom recovers, and that arthrodesis usually insures bony union in one to one and one-half years—it is further suggested that, in proven cases of tuberculosis of the knee joint, immediate arthrodesis should be carried out on patients aged fifteen years or over, except perhaps in the very earliest cases. Again, when skiagraphic evidence of destruction of cartilage is present, arthrodesis is indicated in patients over nine years of age.

3. Arthrodesis is to be condemned before the age of six, and it is probably best to continue immobilization until the age of nine. After the age of fifteen, previous immobilization appears not to hasten bony union.

4. In view of the high mortality from osseous disease when treated by immobilization only (three in ten in this series), it is recommended that operation should invariably be carried out on the bony focus. It may be recalled that, in the cases discussed in this article, operation on the osseous focus did not affect the likelihood of complete recovery of the joint itself, and, in addition, prevented its infection by extension of the tuberculous process in the bone.

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A NEW METHOD FOR ROENTGENOGRAPHIC EXAMINATION OF THE UPPER END OF THE FEMUR *†

BY CLAYTON R. JOHNSON, M.D., LOS ANGELES, CALIFORNIA

Perfect apposition of fragments is an essential factor in obtaining acceptable results in treatment of fractures of the upper end of the femur. With single, anteroposterior examination it is impossible, and with stereoroentgenograms in the anteroposterior position it is often difficult, or impossible, to determine when satisfactory reduction has been accomplished (Figs. 5 and 6). With this point in view we set about to devise a simple, practicable method whereby it would be possible to obtain a comparatively undistorted roentgenogram of the upper end of the femur in the lateral position.

THEORETICAL CONSIDERATION

The neck of the femur, *N* (Figs. 1-A and 2-A), when examined from the anterior position, joins the shaft at an angle of about fifty degrees. By directing the central x-rays perpendicular to a plane which bisects this angle, it is then possible to cast a shadow of *N*, undistorted as to length, on sensitized film *C*, lying parallel to the longitudinal plane of the femoral shaft.

The neck of the femur, N (Figs. 1-B and 2-B), when examined from a lateral position, slopes dorsally with relation to the torso about twenty-five degrees. By directing the central x-rays at an angle of twenty-five degrees below the horizontal plane through the femoral neck, and tilting the plane of film *C* at an angle of sixty-five degrees with the horizontal, a true lateral projection may be obtained without superimposing shadows of other bony structures.

TECHNIQUE FOR EXAMINATION

1. Construct from a heavy piece of cardboard an anglemeter in the form of a right-angle triangle, the angles of which are ninety degrees, sixty-five degrees, and twenty-five degrees (Figs. 1-A and 1-B).
2. Have the patient in a supine position.
3. Place the cassette, *C*, containing the sensitized film, parallel with the longitudinal plane of the shaft of the femur, inclining outward at an angle of sixty-five degrees with the horizontal plane. Determine this angle accurately with the anglemeter (Fig. 1-B). Center the cassette just above the upper margin of the greater trochanter.
4. Use target film distance of thirty-six to forty inches with small cone which casts not more than an eight-inch circle of light on the cassette.

* From the X-ray Department of the Los Angeles County General Hospital.
† Read before a special meeting of the Los Angeles and San Francisco Orthopaedic Clubs at the annual session of the California State Medical Association, May 2, 1932.

Fig. 1-A

Fig. 1-B

Photographs of positions for examination as demonstrated with the skeleton. *T*, cone showing direction of central ray; *N*, neck of femur; *C*, cassette; *M*, anglemeter.

Place the base of the anglemeter (Fig. 1-A) parallel with the longitudinal plane of the shaft of the femur, the altitude in the transverse plane of the femoral shaft, and the hypotenuse on the upper side, its plane passing through the upper margin of the greater trochanter. Direct the central x-rays twenty-five degrees toward the table and in line with the hypotenuse of the anglemeter (Figs. 1-A, 1-B, 2-A, and 2-B).

If the thigh is in a position of abduction, follow the same general plan, always keeping the line of the central rays at an angle of twenty-five de-

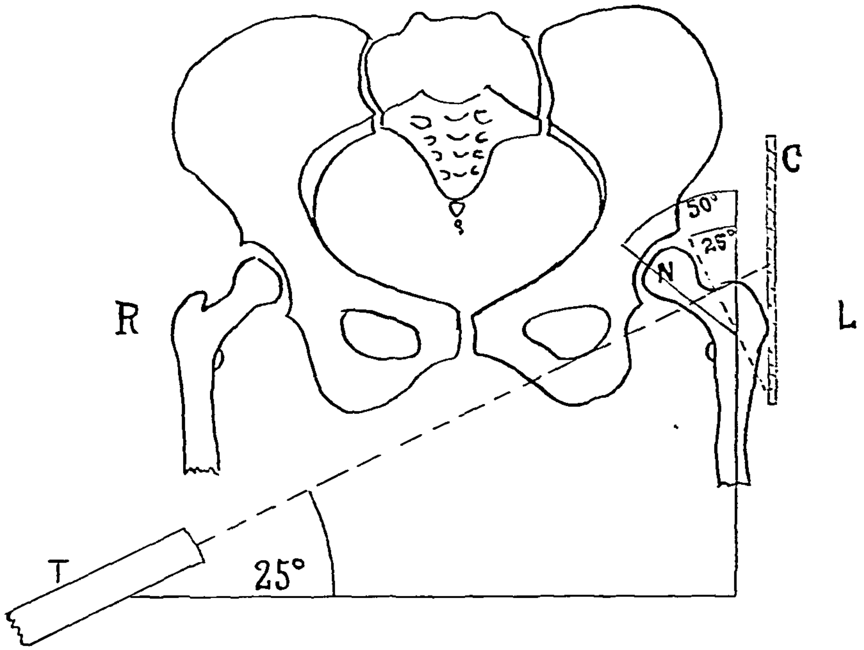

FIG. 2-A

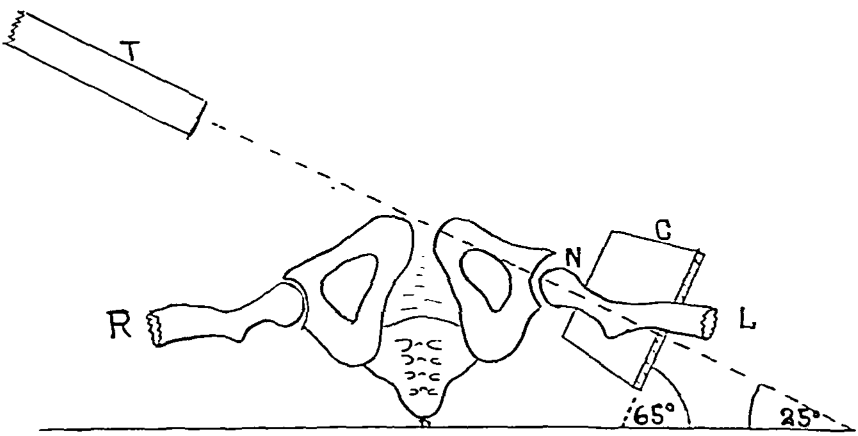

FIG. 2-B

Diagram showing angle of femoral neck, the proper direction of the central ray, and position of the cassette.

grees with the transverse plane of the femoral shaft. All angles must be accurate if distortion is to be prevented.

5. Use suitable exposure for the thickness of the part.

PRACTICABILITY

The examination above described may be accomplished at the patient's bedside or with the patient on the fracture table, with the average portable apparatus. The patient need suffer no discomfort whatsoever from the

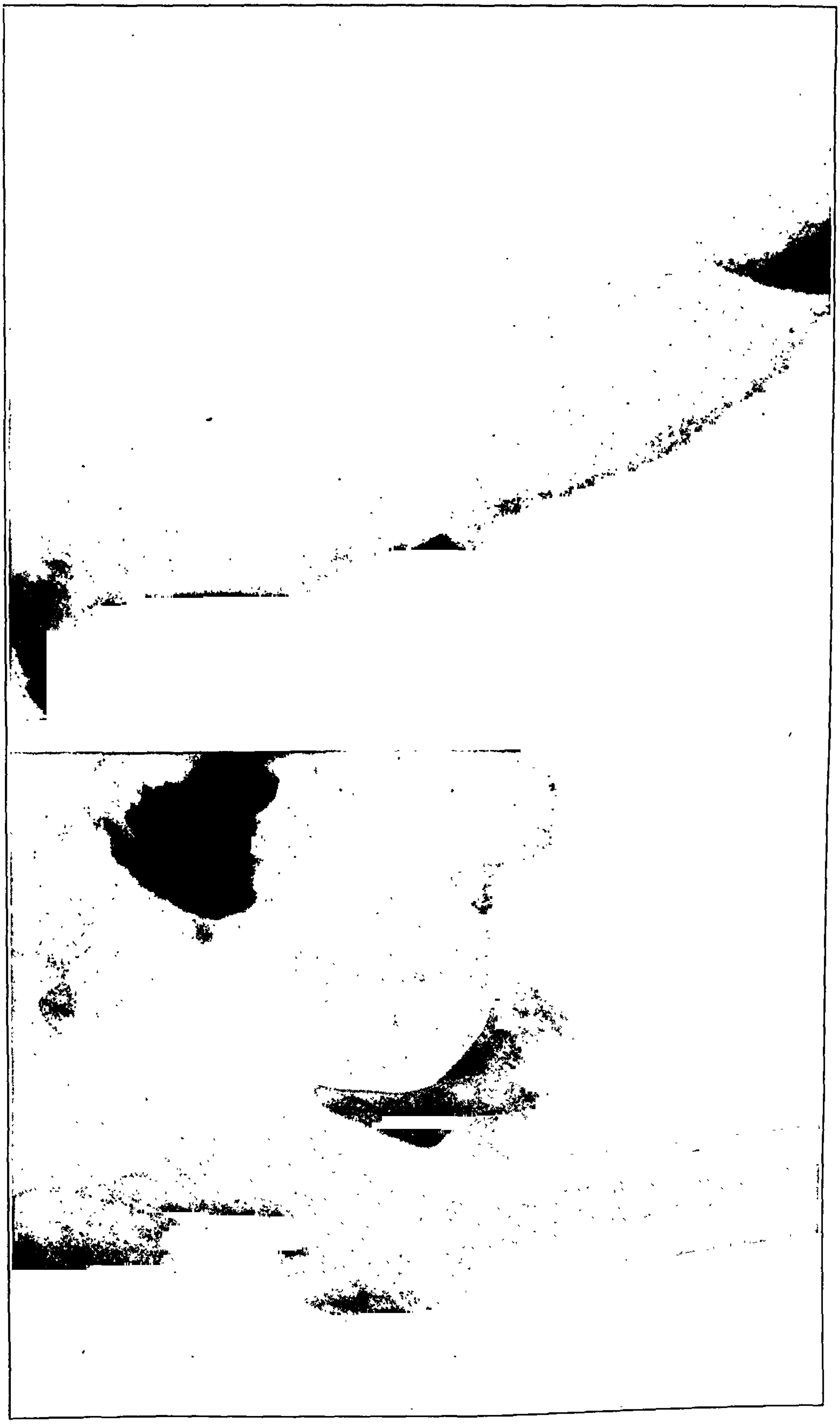

Fig. 3

Upper end of normal femur as shown on anteroposterior and lateral roentgenograms.

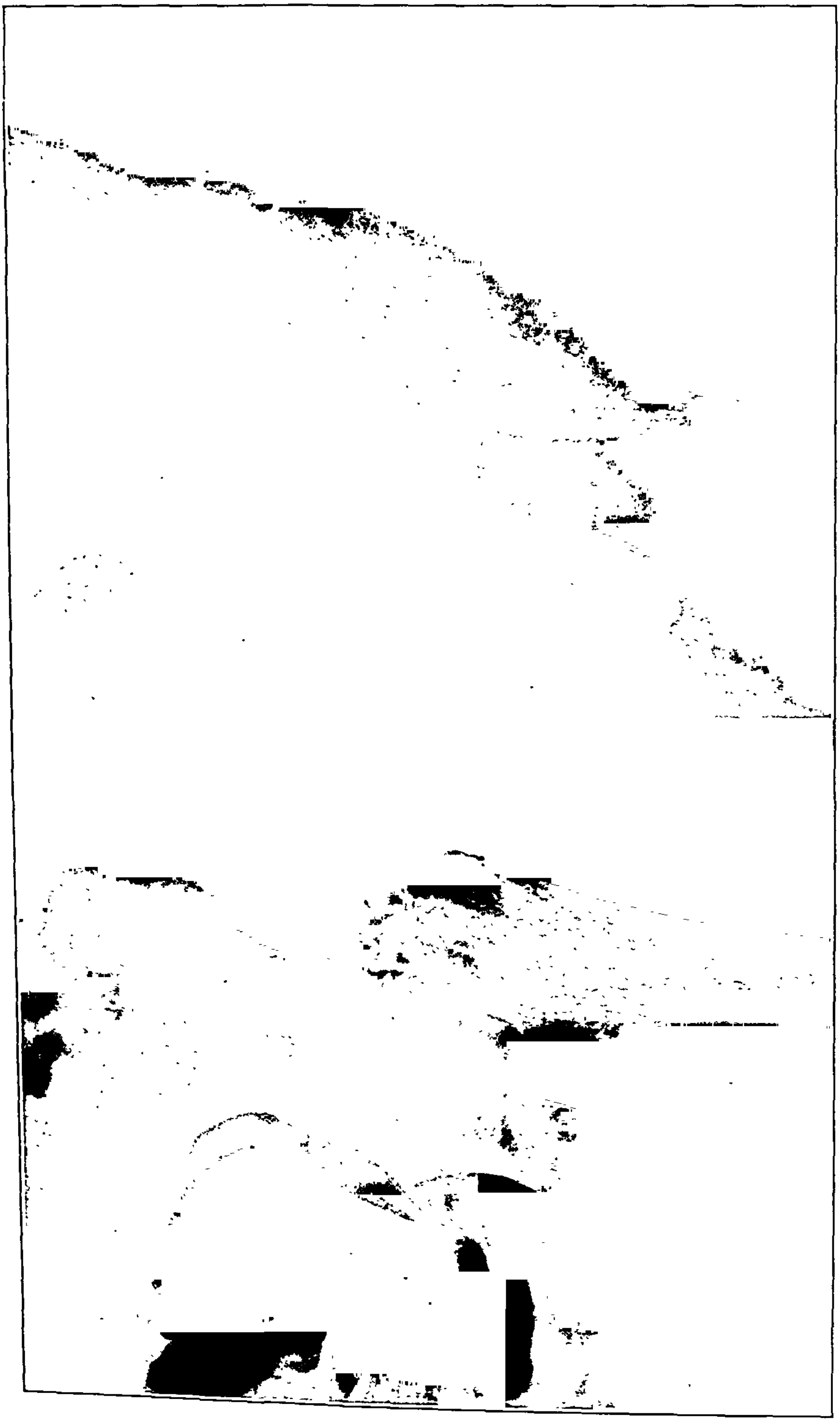

Fig. 4
Upper end of right femur showing usual deformity following fracture of the femoral neck.

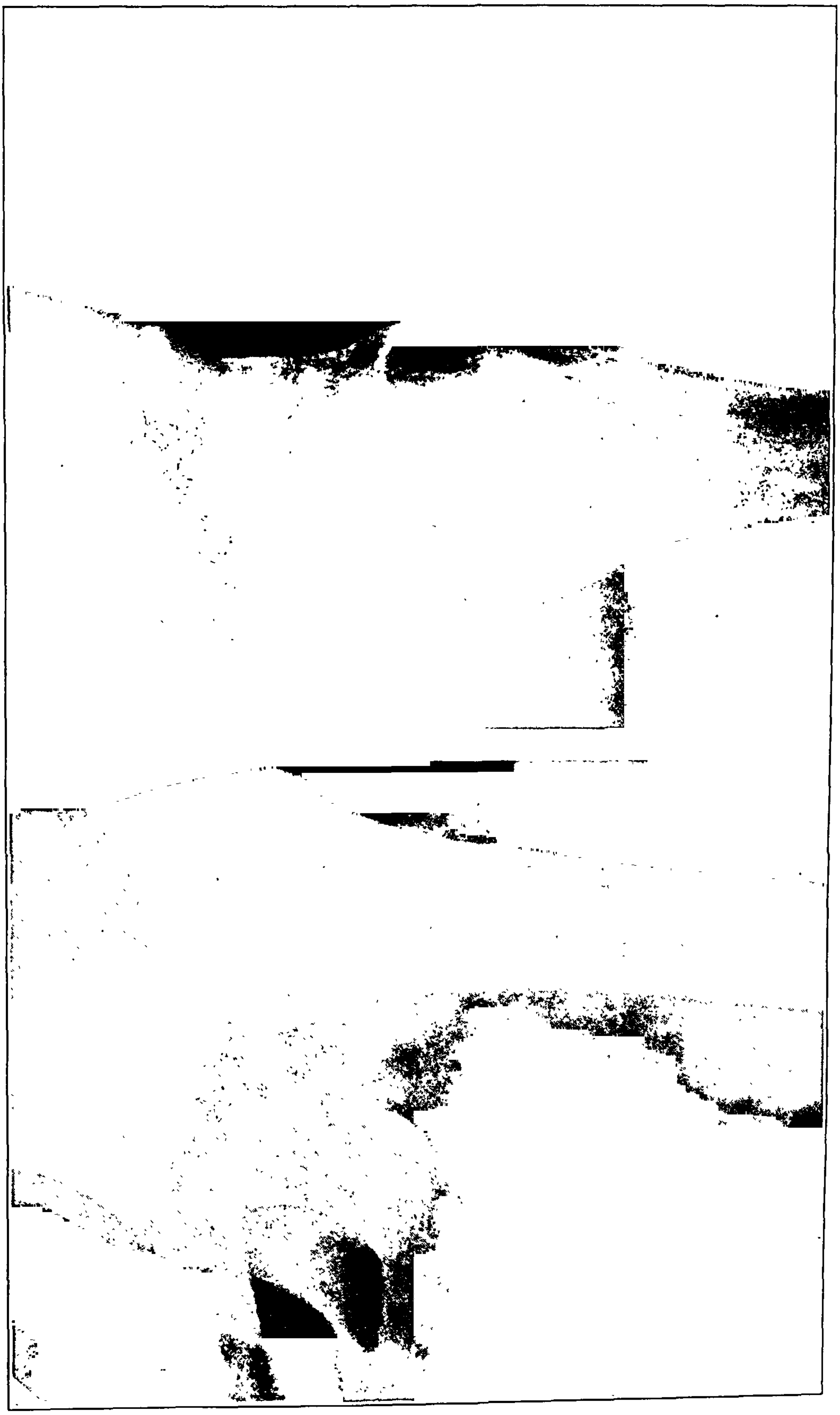

Fig. 5

Same as Fig. 4, following attempted reduction. Anteroposterior view shows good apposition of fragments. Lateral view shows marked medial rotation of the head fragment.

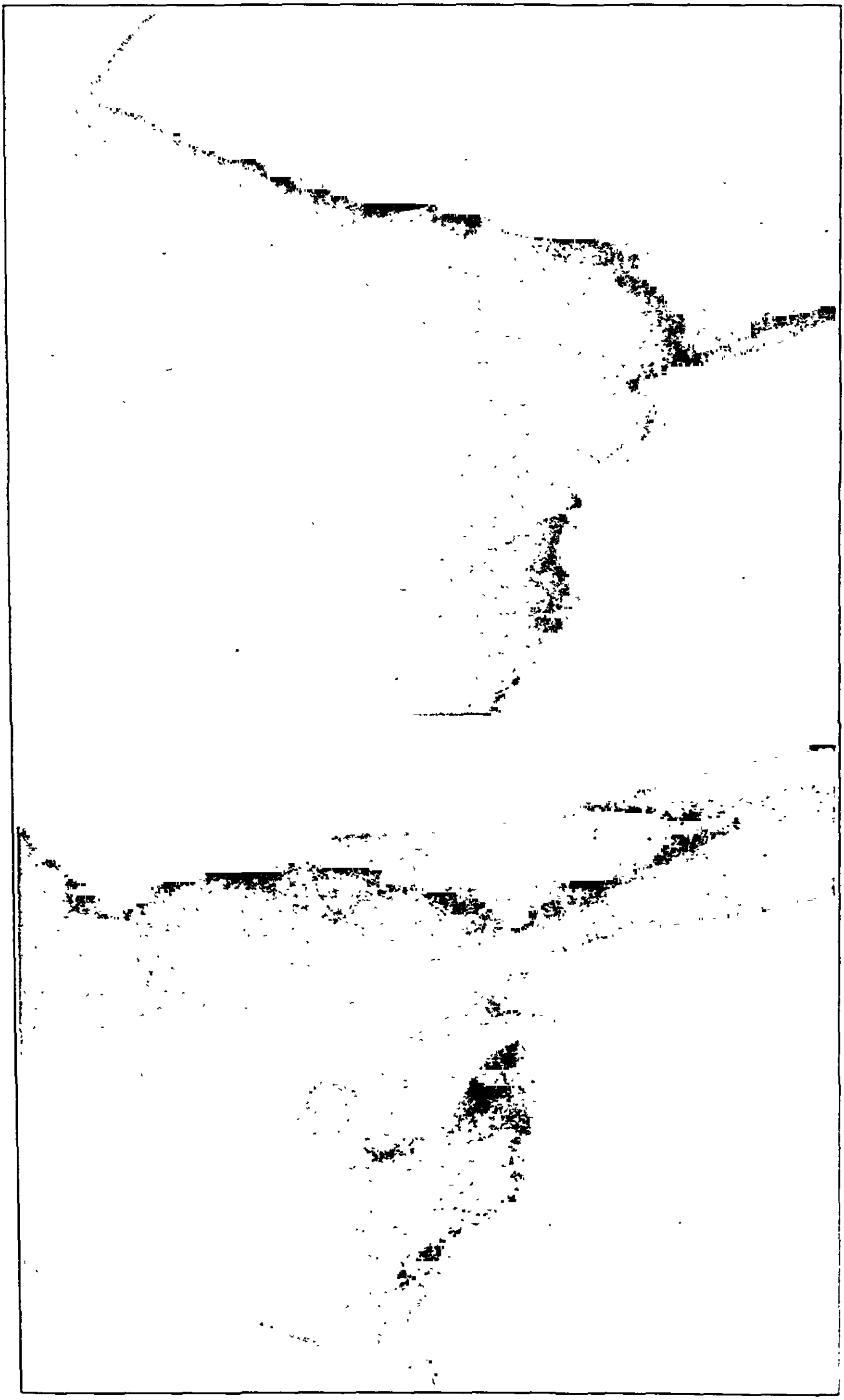

Fig. 6

Following attempted reduction. Intertrochanteric fracture with anterior displacement of the shaft fragment, not detected on the usual anteroposterior roentgenogram.

procedure. The examination may be made entirely satisfactorily regardless of the type of immobilization which may be present.

SUMMARY

1. A method of roentgenographic examination of the upper end of the femur in the lateral position has been presented.

2. The method is particularly adapted to the study of fractures of the upper end of the femur.

3. It has been demonstrated that examination in the anteroposterior position is inadequate in detecting deformity which may be present following fracture and attempted reduction.

PARALYTIC DISLOCATION AT THE HIP IN POLIOMYELITIS *

BY EUGENE R. ELZINGA, M.D., FLINT, MICHIGAN, AND J. ALBERT KEY, M.D., ST. LOUIS, MISSOURI

In patients with extensive paralysis of the muscles of the pelvic girdle it is not unusual to find the paralyzed hip dislocated or to be able to dislocate the hip by flexion, adduction, and internal rotation. In our experience the dislocation has always been posterior and it has always been possible to reduce it with relative ease. As a rule, these patients are not ambulant and, as the hip is not painful, they do not know that it is dislocated nor that the head of the femur can be slipped in and out of its socket at will. However, when the surgeon fits the patient with braces and attempts to make him ambulant, the instability of the hip is found to be a serious handicap and major surgical operations are performed in efforts to make these hips more stable.

For a number of years one of us (J. A. K.) has been interested in these cases and has speculated as to what types of paralysis are apt to result in dislocation and as to whether or not a given type of paralysis will always result in dislocation. From time to time these speculations have taken the form of examining isolated cases of paralytic dislocation of the hip and comparing them with other cases, in which extensive paralysis of the hip was present, in an attempt to determine whether or not it would be possible to prognosticate dislocation in a given case.

The study of isolated cases led to the conclusion that dislocation was apt to occur in paralytic hips in which there were strong flexors and adductors and internal rotators with weak or absent extensors, abductors and external rotators. However, from time to time cases were examined in which this combination had not resulted in dislocation and other cases were examined in which dislocation had occurred without this type of paralysis. As we were unable to find an analysis of paralytic dislocation of the hip in the literature, we decided to review all of the cases which had been seen in the St. Louis Unit of the Shriners' Hospital for Crippled Children and to compare these with a similar group of patients with extensive paralysis of the muscles of the hip in which dislocation had not occurred. It was hoped that this review might throw some light upon the mechanism of the condition.

Since the hospital opened in 1924 we have had twenty-five patients with paralytic dislocation of the hips. In one patient the dislocation was bilateral; consequently we have a series of twenty-six hips which have dislocated as a result of poliomyelitis. These occurred in 953 cases of

* From the Shriners' Hospital for Crippled Children, St. Louis, Missouri, and the Washington University Medical School, St. Louis, Missouri.

TABLE I

	Sex	Name	Side	Present Age (Years)	Age at Onset (Years)	Duration of Disease (Years)	Deformities at Hip	X-ray Appearance: Acetabulum	X-ray Appearance: Coxa Valga	X-ray Appearance: Tilt of Pelvis
Case 1	M	O.W.	L	14	1	13	Slight flexion	Poor	Severe	–
Case 2	F	L.H.	R	16	4	12	None			
Case 3	M	W.S.	R	6	2	4	External rotation	Good	Severe	0
Case 4	F	L.McD.	L	11	?	11	Slight flexion	Poor	Moderate	0
Case 5	M	C.H.	L	12	6 mo.	11	Moderate flexion	Poor	Severe	0
Case 6	M	B.T.	R	16	1	15	Moderate flexion	Fair	Severe	0
Case 7	F	P.D.	R	10	6 mo.	9	Severe flexion	Poor	Severe	+
Case 8	F	M.H.	R	16	1	15	Flexion	Poor	Severe	–
Case 9	F	B.B.	L	7	1	6	Flexion adduction	Poor	Severe	–
Case 10	F	Z.E.	R	18	1	17	40° flexion	Poor	Severe	0
Case 11	M	A.R.	R	16	4	12	Slight flexion	Poor	Severe	–
Case 12	F	R.R.	R	11	6	5	Moderate flexion			
Case 13	F	L.M.	R	11	9 mo.	10	30° flexion	Fair	Moderate	–
Case 14	F	F.R.	R	17	7	10	Moderate flexion	Poor	0	–
Case 15	M	B.R.	L	11	1	10	Slight flexion	Fair	Severe	0
Case 16	M	J.H.	L	9	2	7	None			
Case 17	F	W.B.	R	10	9 mo.	9	90° flexion	Poor	Severe	–
Case 18	M	R.H.	L	7	1	6	45° flexion	Poor	Moderate	+
Case 19	M	E.K.	R	10	1	9	Slight flexion	Poor	Severe	0
Case 20	M	G.B.	L	15	1	14	60° flexion	Poor	Severe	+
Case 21	F	M.B.	R	16	5	11	None	Fair	Moderate	–
Case 22	F	M.B.	L	16	5	11	35° flexion	Fair	Severe	+
Case 23	M	M.C.	R	11	3	8	30° flexion	Fair	Moderate	+
Case 24	M	K.A.	R	11	1	10	Moderate flexion	Good	Severe	+
Case 25	F	H.S.	R	12	4 mo.	12	45° flexion	Poor	Moderate	0
Case 26	M	J.T.	R	13	2	11	None	Poor	Severe	+

Table I. Clinical findings in twenty-six cases of paralyzed hips which dislocated. Muscles are listed as normal, good, fair, and zero. Acetabulum as good, fair, and poor. Coxa valga as severe, moderate, and zero. Tilted pelvis: zero is normal, plus is varus favoring stability, and minus is valgus or tending toward dislocation.

TABLE II

	Sex	Name	Side	Present Age (Years)	Age at Onset (Years)	Duration of Disease (Years)	Deformities at Hip	X-ray Appearance: Acetabulum	X-ray Appearance: Coxa Valga	X-ray Appearance: Tilt of Pelvis
Case 1	M	G.E.	L	11	8 mo.	10	Slight flexion	Good	Moderate	0
Case 2	M	P.A.	L	14	3	11	Slight flexion			
Case 3	F	M.F.	L	14	5	9	None	Good	Severe	–
Case 4	F	Z.E.	L	18	1	17	None	Fair	Severe	0
Case 5	M	E.R.	L	8	1	7	None			
Case 6	M	E.K.	L	10	1	9	None	Good	Normal	0
Case 7	M	J.C.	R	10	1	9	None	Fair	Severe	–
Case 8	F	M.H.	L	16	1	15	Adduction	Good	Severe	+
Case 9	M	R.H.	L	12	9 mo.	11	None	Good	Severe	+
Case 10	M	B.B.	R	13	5 mo.	12	None	Good	Severe	+
Case 11	M	J.G.	R	14	3	11	60° flexion			
Case 12	M	H.C.	R	16	1	15	Moderate flexion	Good	Severe	+
Case 13	M	O.D.	R	9	7	2	None			
Case 14	F	E.C.	L	13	2	11	Slight flexion			
Case 15	M	A.R.	L	16	4	12	Flexion adduction	Good	Moderate	+
Case 16	M	B.R.	R	11	1	10	None	Good	Severe	0
Case 17	M	O.W.	R	14	1	13	None	Normal	Moderate	+
Case 18	F	M.T.	L	10	5	5	None	Good	Moderate	0

TABLE I—*Continued*

CONDITION OF MUSCLES

	Internal Rotators	*Flexors*	*Adductors*	*Abductors*	*Gluteus Maximus*	*External Rotators*	*Tensor Fasciae Latae*	*Quadriceps*	*Inner Hamstrings*	*Outer Hamstrings*
Case 1	Fair	Good	Good	0	Good	Normal	0	Good	Good	Good
Case 2	Good	Good	Fair	Fair	Good	Good	0	0	Good	Good
Case 3	Fair	Good	Normal	0	Good	Good	0	Good	Good	Fair
Case 4	0	Good	Fair	0	Good	Good	Fair	Good	Fair	0
Case 5	Fair	Good	Good	0	Good	Good	0	Good	Good	Good
Case 6	Good	Good	Normal	0	Good	Good	0	0	Fair	0
Case 7	Normal	Fair	Good	0	Fair	Good	0	Good	Good	Good
Case 8	Fair	Fair	Good	0	Fair	Good	0	Good	Fair	0
Case 9	0	Fair	Fair	0	Fair	Fair	0	Good	Good	Fair
Case 10	Fair	Fair	Good	0	Fair	0	Fair	0	Good	0
Case 11	Fair	0	0	0	Fair	Fair	0	0	Fair	Fair
Case 12	0	0	0	0	0	0	0	0	0	Good
Case 13	0	Good	0	0	0	0	0	0	Fair	0
Case 14	0	0	0	0	0	0	0	0	0	0
Case 15	0	0	0	0	0	0	0	0	0	0
Case 16	0	0	0	0	0	0	0	0	0	0
Case 17	0	0	0	0	0	0	0	0	0	0
Case 18	0	0	0	0	0	0	0	0	0	0
Case 19	0	Good	Normal	0	0	Good	0	Good	0	0
Case 20	Fair	0	Fair	0	0	0	0	0	0	0
Case 21	0	0	0	0	0	Fair	0	0	0	Good
Case 22	0	0	0	0	0	0	0	0	0	0
Case 23	Fair	Good	Fair	0	0	Good	0	Good	0	0
Case 24	0	Good	Fair	0	0	Fair	0	Fair	0	0
Case 25	0	0	0	0	0	Fair	0	0	0	0
Case 26	0	Normal	Normal	Fair	0	0	Fair	Normal	Good	0

TABLE II—*Continued*

CONDITION OF MUSCLES

	Internal Rotators	*Flexors*	*Adductors*	*Abductors*	*Gluteus Maximus*	*External Rotators*	*Tensor Fasciae Latae*	*Quadriceps*	*Inner Hamstrings*	*Outer Hamstrings*
Case 1	0	0	0	0	Normal	Good	0	0	Fair	Fair
Case 2	0	Fair	Fair	Fair	Normal	Good	0	Good	Good	0
Case 3	Good	Normal	Normal	0	Normal	Normal	0	Normal	Normal	Normal
Case 4	Fair	Fair	Fair	Fair	Normal	Good	Fair	0	Normal	Normal
Case 5	0	Normal	0	0	Normal	Good	0	Good	Good	Good
Case 6	Normal	Normal	Normal	Good	Normal	Normal	Fair	Normal	Normal	Normal
Case 7	Good	Normal	Good	0	Normal	Normal	0	Normal	Good	Good
Case 8	0	0	0	Fair	Normal	Good	0	Fair	Fair	Good
Case 9	0	0	0	0	Good	0	0	0	0	Fair
Case 10	0	Good	Fair	0	Good	Good	0	0	Fair	Fair
Case 11	Fair	Good	0	Good	Good	Good	0	0	Good	Good
Case 12	Good	Good	Good	Good	Good	Fair	Good	0	0	0
Case 13	Good	Good	Good	0	Good	Good	0	Good	Fair	0
Case 14	Fair	Good	Good	Good	Good	Good	Good	0	Fair	Good
Case 15	Fair	Fair	0	Good	Good	Good	Good	0	Good	Good
Case 16	Fair	0	0	0	Good	Good	0	0	0	Good
Case 17	Normal	0	0	Normal	Good	Normal	Normal	0	Good	Good
Case 18	Good	Good	Good	Fair	Good	Good	Fair	Fair	Fair	Fair

(Continued on next page)

TABLE II—*Continued*

	Sex	Name	Side	Present Age (*Years*)	Age at Onset (*Years*)	Duration of Disease (*Years*)	Deformities at Hip	X-ray Appearance: *Acetabulum*	X-ray Appearance: *Coxa Valga*	X-ray Appearance: *Tilt of Pelvis*
Case 19	F	J.J.	R	11	1	10	None	Good	Severe	0
Case 20	F	C.O.	R	5	1	4	None	Normal	Moderate	0
Case 21	F	M.M.	R	9	4	5	15° flexion			
Case 22	M	D.H.	L	13	5 mo.	12	None			
Case 23	M	B.P.	R	6	2	4	None			
Case 24	F	L.M.	L	11	9 mo.	10	Moderate flexion	Normal	0	+
Case 25	F	B.R.	L	10	6 mo.	9	Flexion	Good	Moderate	+
Case 26	F	R.C.	R	13	1	12	20° flexion	Good	Severe	–
Case 27	M	J.C.	L	10	1	9	None	Good	Moderate	+
Case 28	M	K.K.	R	7	2	5	Moderate flexion	Normal	0	0
Case 29	F	M.H.	R	11	1	10	None	Good	Moderate	0
Case 30	F	M.J.	L	8	3	5	None	Normal	Slight	–
Case 31	F	B.S.	R	10	3	7	None			
Case 32	F	W.Q.	L	9	5	4	None	Normal	0	0
Case 33	F	W.Q.	R	9	5	4	None	Normal	Moderate	0
Case 34	M	R.C.	R	14	2	12	Moderate flexion	Good	Severe	–
Case 35	F	E.H.	L	10	2	8	None			
Case 36	M	G.B.	L	6	9 mo.	5	Flexion			
Case 37	M	E.R.	R	8	1	7	None			
Case 38	F	P.D.	L	10	6 mo.	9	Moderate flexion	Normal	Moderate	–
Case 39	F	M.K.	R	6	2	4	None	Good	Moderate	–
Case 40	M	E.N.	R	9	1	8	Moderate flexion	Good	Moderate	+
Case 41	F	C.O.	L	5	1	4	None	Normal	Moderate	0
Case 42	M	C.M.	L	12	3	9	25° flexion			
Case 43	F	B.R.	R	10	6 mo.	9	Flexion	Poor	Severe	–
Case 44	F	L.H.	L	16	4	12	None			
Case 45	F	M.M.	L	9	4	5	50° flexion			
Case 46	F	H.F.	R	12	6 mo.	11	Moderate flexion			
Case 47	F	H.F.	L	12	6 mo.	11	Moderate flexion			
Case 48	F	M.T.	R	10	5	5	None	Good	Moderate	0
Case 49	F	E.H.	R	10	2	8	None			
Case 50	M	O.D.	L	9	7	2	None			
Case 51	F	C.T.	R	11	1	10	60° flexion			
Case 52	F	M.S.	R	11	3	8	45° flexion	Fair	Moderate	+
Case 53	M	B.P.	L	6	2	4	Flexion			
Case 54	M	J.R.	R	11	3	8	Slight flexion			
Case 55	M	D.H.	R	13	5 mo.	12	60° flexion			
Case 56	F	E.V.	L	13	6	7	Moderate flexion			
Case 57	M	R.R.	R	8	3	5	None			
Case 58	F	R.R.	L	11	6	5	Severe flexion			
Case 59	F	E.M.	L	14	6	8	45° flexion			
Case 60	F	W.B.	L	10	9 mo.	9	90° flexion	Fair	Severe	+
Case 61	M	C.E.	L	16	5	11	70° flexion			
Case 62	M	C.L.	L	12	1	11	None	Good	Moderate	–
Case 63	M	C.M.	R	12	3	9	30° flexion			
Case 64	M	J.H.	R	9	2	7	None			
Case 65	F	B.S.	L	10	3	7	Moderate flexion			
Case 66	M	J.B.	L	14	4	10	90° flexion	Fair	Moderate	+
Case 67	F	M.J.	R	8	3	5	None	Good	Moderate	+
Case 68	F	A.H.	R	10	3 mo.	10	Slight flexion	Fair	Severe	+
Case 69	F	A.H.	L	10	3 mo.	10	Moderate flexion	Fair	Moderate	–
Case 70	F	B.B.	R	7	1	6	Severe flexion	Fair	Severe	+
Case 71	F	F.R.	L	17	7	10	Severe flexion	Fair	Moderate	+
Case 72	M	R.K.	R	11	3	8	90° flexion	Fair	0	–
Case 73	M	R.K.	L	11	3	8	90° flexion	Poor	0	+
Case 74	M	R.H.	R	7	1	6	45° flexion	Fair	Moderate	–
Case 75	M	J.V.D.	L	13	3	10	None	Good	Moderate	0

TABLE II. Clinical findings in seventy-five cases of paralyzed hips which did not dislocate. Nomenclature as in Table I.

TABLE II—*Continued*

CONDITION OF MUSCLES

	Internal Rotators	*Flexors*	*Adductors*	*Abductors*	*Gluteus Maximus*	*External Rotators*	*Tensor Fasciae Latae*	*Quadri-ceps*	*Inner Ham-strings*	*Outer Ham-strings*
Case 19	Fair	Good	Good	0	Good	Fair	0	Fair	0	0
Case 20	0	Fair	0	0	Good	Good	0	Fair	Fair	0
Case 21	0	0	0	0	Good	Fair	0	0	Good	0
Case 22	Fair	Fair	Fair	0	Good	Fair	0	Good	0	0
Case 23	Fair	Fair	0	0	Good	Good	0	0	Good	Good
Case 24	Fair	Good	0	Good	Good	Good	Good	0	Normal	Normal
Case 25	Good	Good	Fair	Good	Good	Good	Normal	0	Good	Good
Case 26	0	Normal	Good	Fair	Good	Good	0	0	Good	Normal
Case 27	0	0	0	0	Good	Fair	0	0	0	0
Case 28	Fair	Good	0	Good	Good	Good	Normal	0	Good	Good
Case 29	Fair	Good	Fair	0	Good	Good	0	0	Fair	Fair
Case 30	Good	Fair	Good	Fair	Good	Good	Fair	Good	Good	Good
Case 31	Good	Fair	Good	0	Good	Normal	0	Normal	Fair	0
Case 32	Fair	0	0	Fair	Fair	Good	0	0	0	0
Case 33	Good	0	0	Good	Fair	Normal	0	0	Fair	0
Case 34	Fair	Good	Fair	0	Fair	Good	0	Fair	0	0
Case 35	0	0	0	0	Fair	0	0	0	0	0
Case 36	0	0	0	Fair	Fair	0	Fair	0	0	0
Case 37	0	Good	Good	0	Fair	Fair	0	Fair	Fair	0
Case 38	Fair	0	0	0	Fair	Good	0	0	Good	Good
Case 39	Fair	Good	Fair	0	Fair	Good	0	0	Fair	Fair
Case 40	Fair	Normal	0	Good	Fair	Good	Good	0	0	Good
Case 41	0	0	0	0	Fair	0	0	0	Fair	Fair
Case 42	0	0	0	0	Fair	Fair	0	0	0	0
Case 43	Fair	Fair	Fair	Fair	Fair	Fair	Normal	0	Fair	Fair
Case 44	Fair	Fair	Good	0	Fair	Good	0	Good	Good	Good
Case 45	0	0	Fair	0	0	0	0	0	0	0
Case 46	0	0	0	0	0	0	0	0	0	0
Case 47	0	0	0	0	0	Good	0	0	0	0
Case 48	0	0	0	0	0	Fair	0	0	0	0
Case 49	0	0	0	0	0	0	0	0	0	0
Case 50	Good	Good	Good	0	0	Good	0	Fair	Fair	Fair
Case 51	0	0	0	0	0	0	0	0	0	0
Case 52	0	Good	0	0	0	Good	0	0	Fair	Good
Case 53	0	0	0	0	0	0	0	0	0	0
Case 54	0	0	0	0	0	0	0	0	0	0
Case 55	0	Fair	0	0	0	0	0	0	Fair	0
Case 56	0	0	0	0	0	0	0	0	0	0
Case 57	0	0	0	0	0	0	0	0	0	0
Case 58	0	0	0	0	0	0	0	0	0	0
Case 59	0	Good	0	0	0	Fair	0	0	0	0
Case 60	0	0	0	0	0	0	0	0	0	0
Case 61	0	Good	0	0	0	0	0	0	Fair	Fair
Case 62	0	0	0	0	0	0	0	Fair	0	0
Case 63	Fair	0	0	0	0	0	0	0	Fair	0
Case 64	0	0	0	0	0	0	0	0	0	0
Case 65	Fair	Fair	Fair	0	0	Good	0	0	0	0
Case 66	0	0	0	0	0	0	Good	0	0	0
Case 67	0	0	0	0	0	Fair	0	0	0	0
Case 68	0	0	0	0	0	0	0	0	0	0
Case 69	0	0	0	0	0	0	0	0	0	0
Case 70	0	Fair	0	0	0	Fair	0	0	0	0
Case 71	0	0	0	0	0	0	0	0	0	0
Case 72	0	0	0	0	0	0	0	0	0	0
Case 73	0	0	0	0	0	0	0	0	0	0
Case 74	0	0	0	Fair	0	Good	0	0	0	0
Case 75	0	0	0	0	0	0	0	0	0	0

infantile paralysis which have been brought to the hospital for treatment, an incidence of a little over two and five-tenths per cent.

The records and x-rays of these twenty-six hips were reviewed and the more pertinent clinical findings were tabulated (Table I). Then a series of seventy-five hips with extensive paralysis, but in which dislocation had not occurred, was selected at random from the hospital records and the clinical findings were tabulated in a similar manner (Table II).

Examination of Table I reveals the fact that in our series dislocation was more common on the right side, there being seventeen cases on the right side and only nine cases on the left side, while bilateral dislocation occurred in only one instance. Sex was not an important factor as the cases were about equally divided between the two sexes. The duration of the disease was important as dislocation did not occur in any case in which the paralysis had not been present for at least four years and in the majority of the cases it occurred in children in which the disease began in infancy. However, neither the age at onset nor the duration of the disease can be considered as definite causes of the condition, because in Table II there are listed a large number of severely paralyzed hips in which the disease began in infancy and in which the paralysis had been present five years or more and yet dislocation had not occurred. The average age at onset in the two groups is approximately the same.

In regard to the presence or absence of deformities, there was a difference between the two groups as only four of the twenty-six hips in which dislocation occurred did not present deformities, while in the similar group of severely paralyzed hips in which dislocation did not occur approximately half of the cases presented no deformity. As a rule, the deformities were flexion deformities and varied from slight permanent flexion to permanent flexion of ninety degrees. This, however, was true in both groups and the percentage of severe deformities was greater in the group in which dislocation did not occur.

It is particularly interesting to note that in many cases the deformity did not correspond to what would be expected from the muscle examination and that severe deformities, even as great as ninety degrees of permanent flexion, might be present in flail hips. Consequently it is obvious that our current belief that deformities are largely the result of muscle imbalance is not entirely true as regards the hip. For instance, in Case 2 of Table I there was a flexion deformity of sixty degrees in the presence of a good gluteus maximus muscle and a good flexor group at the hip. In other words, according to our muscle examination, the flexors and extensors in this case were about balanced and yet the deformity occurred. The same situation occurred in several of the flail hips where, with complete paralysis of the flexors, deformities of from fifty to ninety degrees were present. While it cannot be denied that muscle imbalance plays an important rôle in the production of deformities, it must be admitted that other factors may be of equal importance. We believe that habitual posture was responsible for the deformities in many of our cases.

FIG. 1

X-ray of pelvis in Case 24, Table I. Acetabulum good, severe coxa valga, slight varus deformity of the pelvis.

Our interest was directed especially to the results of the muscle examinations as we believed that the distribution of the paralysis was the important factor in determining whether or not dislocation would eventually occur. We believed that the most important muscle in the prevention of paralytic dislocation at the hip was the gluteus maximus, because all of the cases were posterior dislocations and in all cases the dislocation could be produced by flexing and adducting and internally rotating the hip. In this group we had no cases of anterior dislocation and no cases in which the dislocation occurred in abduction, extension, and external rotation. Consequently, we have arranged our cases in a descending scale as regards the power present in the gluteus maximus,—that is, in the extensors of the hip.

The muscle examination of the hip included the internal rotators, flexors, adductors, gluteus maximus (extensors), external rotators, tensor fasciae latae and abductors. In addition to the above we have also charted the quadriceps and hamstrings. The internal rotators, flexors, and adductors have been placed in sequence and are believed to be the muscles which tend to produce dislocation when they are active and when the gluteus maximus, external rotators, tensor fasciae latae and abductors are paralyzed. We have thus divided the muscles of the hip into two main divisions, the first of which tends to cause dislocation while the second tends to prevent dislocation. We may regard the quadriceps as an accessory muscle of flexion and the hamstrings as accessory muscles of extension at the hip. However, we do not believe that the presence

or absence of power in these muscles has very much to do with the stability of the hip joint.

In our muscle examination we have recognized only four degrees of power: normal, good, fair, and zero. "Zero" includes those muscles which are completely *flail* and those in which there is only a trace of power left, but in which this power is not sufficient to move the joint with all resistance removed. "Fair" includes those muscles which are able to move the joint without resistance, but are not able to lift the limb against gravity. "Good" muscles are those which can lift the limb against gravity, but which cannot take much added resistance, while the "normal" muscle groups are those which to all intents and purposes have normal power for the individual,—that is, they can move against gravity and resistance. We have not used spring balance tests, because our records are not made that way and we are not in a position to give the power of the various groups in pounds. However, the muscle examinations were made by skilled physiotherapists and were checked by the surgeons in charge and we believe them to be satisfactory.

We were surprised to note that in six of the twenty-six cases in which dislocation occurred the gluteus maximus was good, and in five additional cases it was fair,—that is, in eleven of the twenty-six cases dislocation occurred in the presence of definite power in the extensor group. Much the same is true of the external rotators. Apparently the muscles which are most important in lending stability to the hip are the abductors and the tensor fasciae femoris, as dislocation occurred in only two cases with fair abductors and in only three cases with a fair tensor fasciae femoris and in no cases in which these muscles were good or normal. However, it is to be emphasized that these muscles were more frequently paralyzed than any other group, both in the cases with dislocation and in those in which dislocation did not occur.

It is further to be noted that in only one case of the entire group was there a good tensor fasciae femoris in the presence of severe abductor paralysis. It is obvious from this that we rarely have the opportunity

TABLE III

Muscle Groups	Hips That Dislocated				Hips That Did Not Dislocate			
	Normal	Good	Fair	0	Normal	Good	Fair	0
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Internal rotators..	3.8	7.6	30.4	57.6	2.6	13.3	26.6	57.6
Flexors...........	3.8	38.4	15.2	42.2	0.8	24.0	17.3	50.6
Adductors........	15.2	19.2	22.8	42.2	2.6	14.6	14.6	67.2
Abductors........	0	0	7.6	92.3	0.3	13.3	13.3	72.0
Gluteus maximus..	0	22.8	19.2	57.6	10.6	30.6	17.3	40.3
External rotators..	3.8	34.2	19.2	42.2	8.0	41.3	16.0	34.6
Tensor fasciae latae.	0	0	11.4	88.6	5.3	8.0	6.6	80.0
Quadriceps.......	3.8	34.2	3.8	57.6	5.3	8.0	10.6	76.1
Inner hamstrings..	0	30.4	19.2	49.8	5.3	20.6	25.3	48.8
Outer hamstrings..	0	22.8	11.4	65.2	6.6	21.3	13.3	64.8

TABLE III. Percentage of the various muscle groups which were normal, good, fair, and zero in twenty-six paralyzed hips which dislocated and in seventy-five paralyzed hips which did not dislocate.

TABLE IV

Muscle Groups	Dislocating Hips	Hips That Did Not Dislocate
Internal rotators	0.58	0.61
Flexors	1 04	0.90
Adductors	1 08	0.52
Average of three preceding groups	0 90	0.68
Gluteus maximus	0.65	1.11
External rotators	1.00	1.23
Tensor fasciae latae	0.11	0 39
Abductors	0.08	0 44
Average of four preceding groups	0.48	0.79
Average of all muscle groups	0 69	0.73

Table IV. Average power present in the various muscle groups of twenty-six paralytic hips which dislocated and seventy-five paralytic hips which did not dislocate. Normal is 3, good is 2, fair is 1, and zero is 0.

of transplanting the tensor fasciae femoris into the trochanter for abductor paralysis.

We have manipulated the figures obtained from the muscle examination of the two groups in various ways and in Table III we have presented the percentage of the muscle groups in the two series in which the muscles were normal, good, fair, and zero. It will be seen from these tables that the internal rotators were approximately the same in the two groups, while the adductors and flexors were slightly stronger in the group in which dislocation occurred; likewise, the abductors and external rotators and gluteus maximus were stronger in the group in which dislocation did not occur.

By denoting the power in the various muscle groups by numbers and considering normal as 3, good as 2, fair as 1, and zero as 0, we have computed the average power of each muscle group for the entire series. These results are given in Table IV. It is seen that, if we average the power of the internal rotators, flexors, and adductors, we find that the average power of these muscles was 0.90 in the hips which dislocated as contrasted with an average power of 0.68 in the hips which did not dislocate. Likewise, if we average the power in the gluteus maximus, external rotators, tensor fasciae femoris, and abductors, we find that the average power of this second group was 0.48 in the hips which dislocated and 0.79 in the hips which did not dislocate.

From the above it is evident that taken as a group the twenty-six hips which dislocated were characterized by relatively strong flexors, internal rotators, and adductors and relatively weak extensors, external rotators, and abductors. That is, the above was true when these hips were compared with a similar group in which dislocation did not occur. That the two groups are comparable is evident from the fact that the average power of all muscles in the twenty-six hips which dislocated was 0.69 and the average power of all muscles in the seventy-five hips which did not dislocate was 0.73. Thus the average muscle power in each group

Fig. 2

X-ray of pelvis in Case 23, Table I. Acetabulum fair, moderate coxa valga, and definite varus deformity of the pelvis.

was less than fair, which is 1, and the difference between the two groups was 0.04.

From Table IV we can formulate a rule that severely paralyzed hips with relatively strong flexors, adductors, and internal rotators and relatively weak extensors, external rotators, abductors and tensor fasciae femoris may be expected to dislocate. It is further evident that relatively strong adductors combined with relatively weak abductors and tensor fasciae femoris are especially liable to result in dislocation.

However, examination of Tables I and II reveals many exceptions to the above rules. In seeking an explanation for these exceptions we have studied the available roentgenographs of the pelves and hips of both series in order to determine whether or not the form of the pelvis and hip could be considered a causative factor in the dislocation.

The points to which we paid particular attention were the depth of the acetabulum, the tilt of the pelvis, and the angle of the neck of the femur. In considering these factors we have classified the acetabula as poor, fair, good, and normal. Since in all of the femora the angle of the neck was increased we have classified these as severe, moderate, and slight coxa valga. As regards the tilt of the pelvis, we have classified these as varus, valgus, and normal pelves. It is to be noted that by a varus or valgus pelvis we mean one in which the os *innominatum* as a whole is

deviated inward or outward, and we do not refer to a bending inward of the ischium as varus.

The terminology which we have used in classifying these pelves is best understood by referring to Figures 1, 2, and 3.

In Figure 1 is shown a paralytic hip which dislocated and in which the acetabulum is good, but not quite normal. In this case there is a severe coxa valga—that is, the neck of the femur is almost in line with the shaft and the pelvis is approximately normal, although it might be considered as showing a slight varus deformity.

In Figure 2 is shown a hip in which the acetabulum is considered fair. This acetabulum is fairly deep and fairly well formed. There is a moderate coxa valga and definite varus deformity of the pelvis.

In Figure 3 is shown a hip in which the acetabulum is poor. It is quite shallow and definitely offers inadequate support for weight-bearing. In addition to this there is severe coxa valga and a valgus deformity of the pelvis,—that is, slight flaring of the pelvis so that the acetabulum faces almost directly outward.

In considering these three factors it is evident that the better the acetabulum the more stable the hip. We have also assumed that the more nearly normal the angle of the neck of the femur, the less likely is

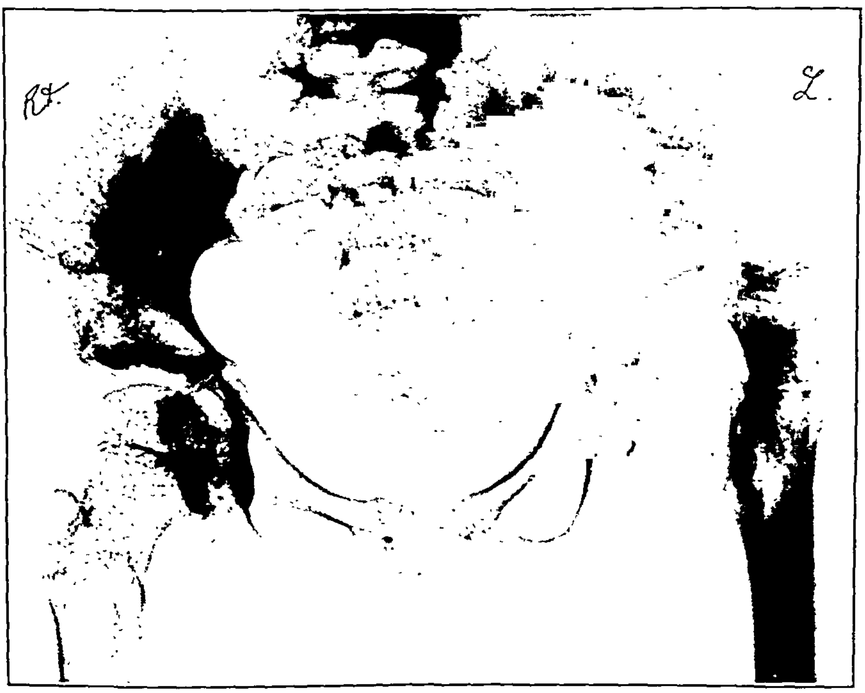

Fig. 3

X-ray of the pelvis in Case 1, Table I. Acetabulum poor, severe coxa valga, and a valgus deformity of the pelvis.

dislocation to occur; and we have considered that a varus deformity of the pelvis would tend to prevent dislocation, while a valgus deformity would tend to promote dislocation, as a varus deformity would tend to render the floor of the acetabulum more nearly horizontal, while a valgus deformity would tend to render it more nearly vertical and thus the latter would lessen the stability of the hip.

In Table V are shown the results of the x-ray studies on twenty-three of the dislocating hips and forty-four of the hips which did not dislocate. From this table it is evident that the acetabula were much poorer in the hips which dislocated. Likewise, severe coxa valga was more marked in the hips which dislocated. On the other hand, the tilt of the pelvis apparently had relatively little to do with the condition. In other words, the hips in which paralytic dislocation occurred tended to have poor acetabula and severe coxa valga when compared with a similar group of severely paralyzed hips. However, we are not in a position to state that the dislocation was the result of the abnormalities in the contours of the pelvis and femur, because it is obvious that these abnormalities may be the result rather than the cause of the dislocation.

We have also studied the heads of the femora in our cases and were surprised to find that, while they tended to be small as a result of the atrophy of disuse, they presented relatively slight deviations from the normal in contour.

TREATMENT OF PARALYTIC DISLOCATION

Prevention. Probably the most important factor in the treatment of these cases is prevention. Our observations indicate that the position of flexion, adduction, and internal rotation is a vicious one in severely paralyzed hips. Consequently we believe that all patients with severe paralysis at the hip, and especially those in which the abductors, external rotators, and extensors are paralyzed, should spend much of their time in a position of abduction, extension, and external rotation. In other words, flexion and adduction deformities should be prevented by conservative methods and these patients should acquire the habit of sitting and sleeping with the knees separated, as we believe that abduction is even more important than extension in preventing dislocation. If this plan is consistently adhered to, we feel that relatively few paralyzed hips will dislocate regardless of the distribution of the paralysis.

In our twenty-six cases the treatment was as follows:

Eight cases are still under observation. Two of these are too young for operation and in one the general condition is so poor that operation cannot safely be undertaken at this time. One is on the waiting list to enter the hospital for operation and four are being treated in abduction with the hope that the tendency to dislocate will subside. One case was not treated because the paralysis was so severe that we thought stabilization of the hips would be useless as it would not be possible to get the patient up on her feet even after the hips had been stabilized. One patient

TABLE V

Dislocating Hips						Hips That Did Not Dislocate					
Acetabulum		*Coxa Valga*		*Tilt of Pelvis*		*Acetabulum*		*Coxa Valga*		*Tilt of Pelvis*	
Poor	15	Severe	16	Varus	7	Poor	2	Severe	15	Varus	18
Fair	6	Moderate	6	Valgus	8	Fair	11	Moderate	22	Valgus	12
Good	2	Normal	1	Normal	8	Good	22	Normal	7	Normal	14
Normal	0					Normal	9				

TABLE V. Deformities in the pelvis and the neck of the femur present in the x-rays of twenty-three paralyzed hips which dislocated and of forty-four paralyzed hips which did not dislocate.

gets along fairly well with crutches and braces and the dislocation causes relatively little trouble. Consequently operation is not contemplated at this time. In one case the tendency of the hip to dislocate disappeared after treatment in abduction. This we regard as a cure by conservative means. In one case there was a spontaneous recovery,—that is, a hip which could formerly be dislocated at will is now stable and it is not possible to produce dislocation. Operation was recommended in fourteen cases. Six of these refused operation and consequently were not treated. Eight of the cases were operated upon.

In all of the operated cases the operation performed was a shelf operation. In most instances the shelf was taken from the side of the ilium. In one instance one of us (J. A. K.) secured a graft for a shelf from the tibia by the simple method of taking a curved gouge and driving it into the bone from below upward so that a wide curved graft was lifted up. Then, beginning about two inches higher, the gouge was driven from above downward so that the curved graft was removed entirely from

FIG. 4

X-ray of the pelvis in Case 10, Table I. Acetabulum poor, severe coxa valga, and normal tilt of the pelvis. Small shelf made from curved tibial graft. Result good three years after the operation.

Fig. 5

X-ray of pelvis in Case 8, Table I. Acetabulum poor, severe coxa valga, and valgus deformity of the pelvis. Large shelf taken from the ilium. Result good three years after the operation.

the bone. With the concave periosteal surface downward one edge of the graft was set into a groove above the rim of the acetabulum (Fig. 4).

In seven of the shelf operations the results were good. In one it was only fair. Although in this case the hip was quite stable the shelf was placed so high that it did not prevent the head of the femur from riding up on the superior margin of the acetabulum. It is interesting to note that every shelf operation was different and that the clinical result was just as good in the cases in which a small shelf had been accurately placed as in the cases in which a large shelf had been folded downward from the ilium. In other words, the size of the shelf seemed to have relatively little to do with the success of the procedure (Figs. 4 and 5). It is, of course, possible that the immobilization in abduction which followed the shelf operation had a good deal to do with the ultimate success in some of the patients.

SUMMARY

A comparison of twenty-six paralytic dislocations of the hip with seventy-five severely paralyzed hips which did not dislocate reveals the fact that no definite type of paralysis was responsible for the dislocation, but that dislocation was most frequent in hips with strong flexors, adductors, and internal rotators and weak extensors, abductors, and external rotators. Of the above muscle groups the abductors appeared to be the most important in maintaining the stability of the hip as we had no cases in which dislocation occurred in the presence of good abductors.

A study of the x-rays of these cases revealed the fact that in paralytic hips which had dislocated the acetabulum was poor and severe coxa valga was usually present. However, it is to be emphasized that these deformities were probably the result of the paralysis and dislocation rather than the cause, as we do not believe that there were any congenital abnormalities in these cases.

We were impressed by the fact that nearly all of the hips which dislocated presented a definite deformity. As any severely paralyzed hip is liable to dislocate, we believe that the prevention of deformities is especially important in these cases. We were further impressed by the fact that the deformities were not always the direct result of muscle imbalance, but in many cases seemed to have been the result of habitual posture. Consequently, we believe that patients with severely paralyzed hips should spend much of their time with the hips in a position of extension and abduction and external rotation.

Operative treatment should be considered in those cases in which conservative treatment has failed or in which there is no reasonable hope that conservative treatment (that is, correction of deformities and maintenance of abduction) will lead to a cure. Contra-indications to operation are such poor general condition that the operation would be unusually dangerous, and such extensive paralysis that even with a stable hip it would not be possible for the patient to walk on crutches and braces. The operation recommended is the shelf operation and we believe that an accurate placing of the shelf is more important than its size, as we have found small shelves just as efficient as large ones.

A NEW METHOD OF DETERMINING PRESENCE OF UPWARD DISPLACEMENT OF THE GREAT TROCHANTER*

BY NATHAN H. RACHLIN, M.D., BROOKLYN, N. Y.

The usual procedure of examining by measuring from the anterior-superior spine of the ilium to the inner malleolus indicates only relative shortening as compared with the opposite side, and is so prone to error, even in experienced hands, that no two measurements are alike, especially in obese people.

Likewise, the method of utilizing Nélaton's line is for the same reason uncertain and has an added disadvantage, that of moving the patient about.

Bryant's triangle does not give us landmarks of sufficient prominence to guide us correctly in all cases.

The method described here is based upon the linear alignment of the crests of the pubic bones in relation to the great trochanters. The procedure is as follows: draw a horizontal line across the crests of the pubic

FIG. 1

Shows roentgenographic view of these landmarks in a normal pelvis.

* From the Orthopaedic Services of the Kings County, Neurological, and Beth Moses Hospitals.

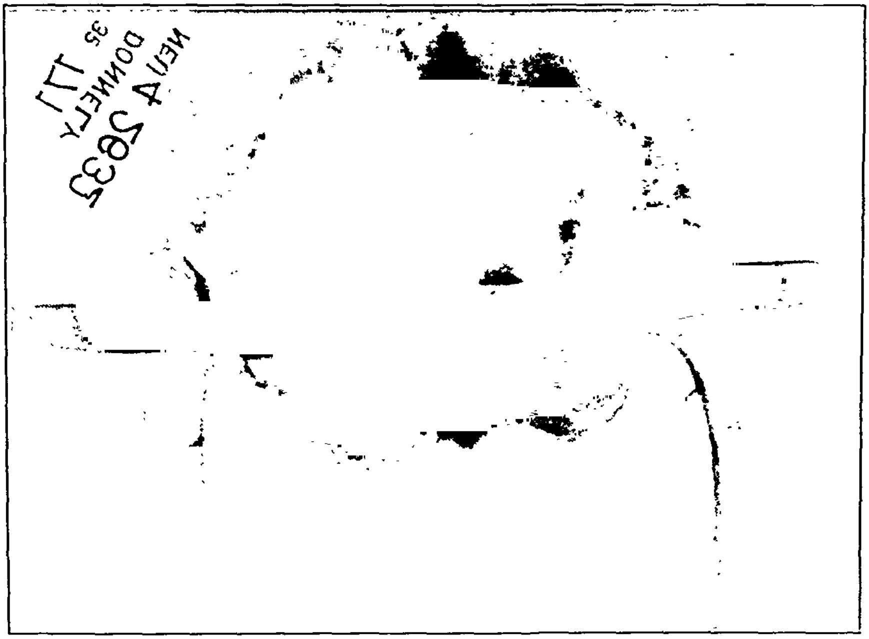

FIG. 2
Shows the disturbed relations in a fractured hip.

bones, at right angles with the umbilicus. This will, on its outer aspect, be opposite the prominent and most palpable part of the great trochanters and about one-half to three-quarters of an inch below their superior borders. These findings were confirmed by a clinical study, checked by roentgenograms.

Variations from this rule are noticed in patients who have exceptionally narrow pubic bones, which necessarily brings their level down to a lower horizontal plane, and in those who have exaggerated posterior curving of the sacra, as in spondylolisthesis, etc., thus raising the plane of the trochanters to a higher level. However, the relative position of the trochanters in relation to each other can still be located with certainty.

This method commends itself because of its simplicity and the ease of finding the landmarks even in very fat people.

Cases where one or both trochanters are markedly above the indicated line would strongly suggest upward displacement of the heads of the femora.

A NEW TREATMENT OF INTRACAPSULAR FRACTURES OF THE NECK OF THE FEMUR AND CALVÉ-LEGG-PERTHES' DISEASE*

BY E. J. BOZSAN, M.D., F.A.C.S., NEW YORK, N. Y.

From the Division of Skeletal Surgery, Morrisania City Hospital, New York

In spite of the best modern efforts, union in some cases of intracapsular fractures of the neck of the femur, in the young as in the aged, is not obtained. An explanation of this failure as well as a method to overcome it has not as yet been found. Cancellous bone unites rapidly and firmly. Failure of fragments of cancellous bone to unite when brought in apposition, in cases of intracapsular fracture, may, perhaps, be explained as follows: The proximal fragment, though apparently one piece, is made up of two segments,—one is the true head, the other is a portion of the neck. The two are separated by a boundary line situated at the site of the epiphyseal plate. The blood supply from the round ligament as it traverses the obstacle of this boundary line is markedly diminished. The distal segment of the proximal fragment, because of this fact, degenerates, becomes partially necrotic, and loses the capacity for callus formation. How soon this occurs after accident is under investigation. If wide communication between the two sections of the proximal fragment is afforded and wider openings through the distal fragment are made, propensity of the cancellous bone for union will be reestablished.

The method of obtaining the desired communication and increasing the circulation is to establish minute channels throughout the length of the neck of the femur from the body of the greater trochanter, well into the head, and so to establish an artificial irrigating system.

The first trial was successful. The good result was the more striking as the case was that of a patient whose intracapsular fracture had been discovered only four weeks before, and the operation was not performed on account of the general condition of the patient until six weeks after the accident, when there was considerable absorption in the neck as demonstrated by the x-ray findings.

It would seem that, if firm bony union resulted in a case fraught with the above mentioned handicaps, it might be reasonably hoped that, if the operation were performed soon after the accident at the time of reduction, a similar good result might follow.

Case 1. Miss E. C. (21316), aged fifty-four, suffered an accident on May 7, 1931. She was treated in a private hospital for the consequences of a fractured skull; she was totally unconscious most of the time, and disoriented at the time of her admission to the Morrisania City Hospital on June 3, 1931. The left foot was in marked eversion and some shortening existed. A roentgenogram of the left hip, taken on June 4, revealed a complete intracapsular fracture of the neck. The drilling operation was

*Cases presented on November 10, 1931, before the Clinical Society of the Hospital for Joint Diseases, and February 9, 1932, at the Morrisania City Hospital before the New York Fracture Committee.

FIG. 1

Case 1. Roentgenogram, taken June 4, 1931, shows a complete intracapsular fracture with marked external rotation of the shaft, and the distal fragment displaced in front of the proximal.

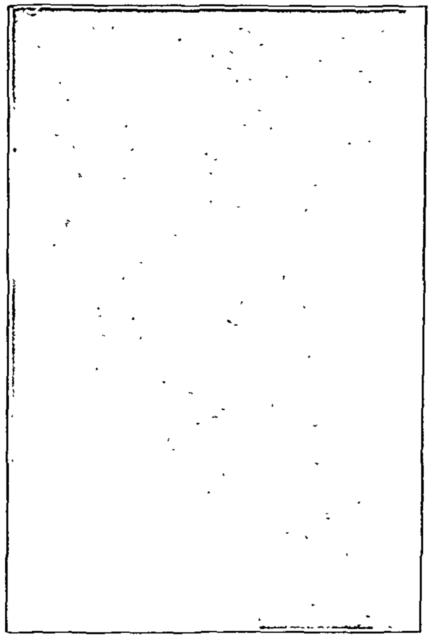

FIG. 2

Case 1. Roentgenogram, taken June 24, 1931, during attempts at improving reposition after operation; indicates a marked area of absorption in the distal fragment.

FIG. 3

Case 1. Shows the best reposition obtained June 27, 1931.

FIG. 4

Case 1. Roentgenogram, November 27, 1931, shows complete and firm bony union of the two fragments.

FIG. 5

Case 2. Roentgenogram, taken August 29, 1930, shows the very early beginning of the process in the head.

FIG. 6

Case 2. Roentgenogram of January 13, 1931, reveals the destruction at its height; shows a large sequestrum in the periphery of the head and absorptive changes in the whole head and part of the neck.

FIG. 7

Case 2. Roentgenogram, taken November 5, 1931, reveals the sequestrum well healed in the head; the outline of the head almost entirely spheric, flattened only at the site of the former sequestrum, the density of the head restored, and absorptive areas filled out.

performed on June 17 and, after repeated attempts to improve the apposition of the fragments, a plaster cast was applied on June 23, and the patient was confined in this for sixteen weeks. At the end of the eighth week, the cast was bivalved, the anterior shell was removed, and cautious passive and active exercises were performed daily until the patient was able to execute straight leg raising when out of the posterior shell. At the end of the sixteenth week, a straight caliper brace was applied, and the patient was allowed to walk about on crutches. The brace and the crutches were gradually discarded and the patient was walking with the aid of a cane seven months after the operation. The roentgenograms (Figs. 1, 2, 3, and 4) here reproduced represent the different stages.

The adoption of the same method of treatment for Calvé-Legg-Perthes' disease was based on my conception of this disease, or rather of a group of pathological manifestations in the neck and head of the femur as being secondary changes, due to impairment of circulation caused by traumatic compression-planes in the neck and on the head. The detailed explanation and illustration of this conception cannot be given space in this brief report.

Upon conveying a fresh blood supply to the affected areas, cessation of degenerative changes may be expected. The first case fully confirmed this expectation.

Case 2. Miss S. R. (7665), aged twelve, suffered a minor accident while bob-sleighing, in March, 1930. Slight disability of the right hip developed during the months of June and July and she was treated in the Out-Patient Department of the Morrisania City Hospital. As the disability progressed, and the roentgenograms, taken on August 29, 1930, revealed degenerative bone changes in the neck and head of the right femur, the patient was repeatedly seen at the same hospital until December 3, 1930. As the roentgenograms revealed rapid progress of the degenerative process in the head and neck after several examinations, including tuberculin tests, the drilling operation of the neck and head was performed January 31, 1931. Three longitudinal channels were drilled in the axis of the neck from the greater trochanter into the head, and two transverse channels from the trochanter into the neck. A plaster spica was applied after which cautious, gradual active and passive exercises were performed daily and the patient was discharged May 2, 1931, with completely free motions and painless weight-bearing at the right hip joint. An x-ray follow-up revealed rapid restoration of the destroyed areas in the head. Patient presented herself last on February 9, 1932, at which time she walked without pain or limp and all motions were equally free in both hip joints. The accompanying roentgenograms (Figs. 5, 6, and 7) reveal the three outstanding stages in the development and recovery.

Since January, 1931, this operation has been performed twenty-four times for intracapsular fracture of the neck of the femur and nine times for different forms of degenerative processes in the neck and head of the femur with uniformly satisfactory results. Obviously, however, a minimum of eight to ten months is required for a definite and clear demonstration of the results, and therefore the reports of the other cases cannot be included in this communication, which is published with an appeal for trial.

CONGENITAL FUSION OF THE BONES OF THE FOOT; WITH A REPORT OF A CASE OF CONGENITAL ASTRAGALOSCAPHOID FUSION

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Congenital fusion of certain bones of the body is seen at times without causing any symptoms. This condition is mainly found in bones undergoing gradual regressive development, the joints between these bones having very little mobility,—for example: the normally present fusion of the sacral and coccygeal vertebrae of the human skeleton.

The joints of the human foot have suffered a great loss of mobility as compared with the clasping foot of the primates. This was necessary since man adopted upright posture, and the human foot had to provide a firm foundation for the body.

A number of cases of congenital fusion of the bones of the foot have been recorded. The most commonly observed is the fusion of the two distal phalanges of the fifth toe. Congenital fusion may occur in the joints between metatarsals and cuneiforms, the cuneiform and cuboid, the calcaneum and scaphoid, the astragalus and calcaneum, and the astragalus and scaphoid, the latter being extremely rare. Also, multiple combination of these fusions may be found.

Engel reported two cases of multiple and bilateral fusion of bones in hands and feet, where astragaloscaphoid fusion was also present.

Lagrange described a case of, what he thought to be, a congenital fusion of the foot joints. In a cadaver of a woman forty-six years of age both scaphoids were fused with the three cuneiforms, and the second and third metatarsals were in turn fused with the cuneiforms; the cuboids were also fused with the fourth and fifth metatarsals.

Leboucq discussed calcaneoscaphoid and astragalocalcaneal fusions. He proved that this condition may undoubtedly be of congenital nature, due to failure of development of the articular cavity during the differentiation of the embryonic cartilages. Leboucq saw calcaneoscaphoid fusion in a foetus of twenty-five millimeters, and astragalocalcaneal fusion in one of sixty-five millimeters.

Pfitzner, Morestin, Dwight, Zoja, Slomann, Badgley, Bargellini, Esau, Wagoner, and others reported cases of congenital fusion of the bones of the feet.

The congenital astragaloscaphoid fusion should be considered as an extremely rare and unusual occurrence, because even such thorough students of the variation of the foot skeleton as Pfitzner and Dwight have

* From the Service of Dr. Leo Mayer.

never seen a single case of a real congenital fusion between the astragalus and the scaphoid. Pfitzner observed only one case of astragaloscaphoid fusion,—in one foot (left) of a woman sixty-four years of age with marked osteo-arthritic changes. After thorough maceration of the foot skeleton, he was able to separate the astragalus from the scaphoid bone.

The only case of astragaloscaphoid fusion described by Morestin was also not of congenital nature. He believed it to be due to an old infection.

Anderson, dissecting a cadaver of a man thirty-four years of age with unavailable clinical history, found bilateral astragaloscaphoid fusion. He published this case in 1879, and it seems to be the first case of real congenital astragaloscaphoid fusion reported. According to Anderson "In carnivora, cheiroptera, and many rodents (mus, castor, hydrochoerus), and in many insectivora, a scapholunar bone is present. In pteropus of the cheiroptera, the cuneiform unites with the scapholunar in the foot. In crocodilia the scaphoid and astragalus coalesce to form an astragalo-navicular bone. . . . In the carpus, the scaphoid and lunar unite (carnivora), scapholunar and cuboid (pteropus), scaphoid and trapezium (sloth and megatherium). In comparing the bones of the carpus and tarsus, the astragalus may be regarded as the homologue of the lunar (Vicq d'Azyr), or as corresponding to the united scaphoid and semi-lunar (Gegenbaur). The scaphoid in the foot, on the other hand, may be regarded as equivalent to the scaphoid in the hand. . . ."

Thus, the astragaloscaphoid fusion observed in the human foot may possibly be considered a homologue of the scapholunar bone of the carpus of carnivora.

In 1918 Holland described two cases which, he thought, were "the rarest varieties of the congenital abnormalities" of the tarsus and the carpus. These were the first two cases that he had ever seen in twenty-one years' experience as roentgenologist, watching for the abnormalities of the extremities. The first case presented multiple fusion between tarsal and metatarsal bones of the right foot in a man thirty-three years of age. The left foot was clinically and roentgenologically perfectly normal. This case is a rather doubtful one in regard to congenital origin of the fusion, as in early childhood the patient had had some operative intervention on the right foot; there had been also a scar and extreme pain and tenderness on mere touching over the dorsum of his right foot ever since the patient could remember. On the contrary, Holland's most interesting second case of a woman twenty-one years of age with bilateral and symmetrical fusion of tarsal and carpal bones is undoubtedly a congenital anomaly. There was fusion of astragaloscaphoid and calcaneocuboid joints, and the second and third metatarsals were fused to their respective cuneiform bones. The carpal bones also presented bilateral anomalies. In May 1928 a case of unquestionable congenital astragaloscaphoid fusion (only in the right foot) was published by Illievitz. His patient, a boy seventeen years of age, had only four metatarsal bones on the right foot, while the left one presented no abnormalities.

In December 1928 Bullitt reported a case of bilateral congenital astragaloscaphoid fusion in a man thirty-five years of age. This condition was an incidental discovery during roentgenographic examination for sprained ankle. It is interesting that the roentgenograms also showed bilateral presence of a very large accessory scaphoid.

A most instructive observation, illustrating how very cautious one should be in pronouncing the fusion of foot joints as congenital, was made by Haglund. He described a case of a young lady, twenty-two years of age, who at the age of eleven was his patient, suffering with tuberculosis of the left astragaloscaphoid and scaphocuneiform joints. She was treated with immobilization by means of a plaster casing and was completely cured. Thirteen years later, when reexamined as a matter of follow-up, the patient presented, roentgenographically, the most perfect astragaloscaphoid fusion, without the slightest suggestion of preexisting tuberculosis. Haglund showed in his article the original roentgenograms and the ones taken thirteen years later, and concluded that this case could be very easily mistaken for a congenital fusion. Nothing was said about the right foot, but presumably it was normal.

On August 5, 1930, a girl, nine years of age, was seen by the writer at the Foot Department of the Hospital for Joint Diseases, complaining of "lumps" over the medial aspect of her feet. The child's mother first noticed the "lumps" about three years before admission when the girl was six years of age, and stated that the prominences had been gradually growing larger. There was no history of any previous injury of the feet or any sickness. The patient had occasional pain due to pressure of the shoe against the prominent part of the foot, but she could walk without any discomfort. The girl was the youngest in a family of two children, and had a perfectly normal brother thirteen years of age. Both parents were alive and quite healthy. There was no history of any deformities in the family. The patient had always been quite well, except for the usual diseases of childhood.

On examination it was found that the patient was a perfectly healthy and well developed child. Her feet were moderately pronated with fairly well preserved longitudinal arches. There was a bony projection (Fig. 1) about two centimeters in diameter over the medial aspect of each foot, corresponding to the location of the medial tuberosity of the scaphoid bone. The projections were covered with a bursa and somewhat reddened skin, but they were not tender. There was a slight limitation of supination and adduction of the forefoot somewhat more

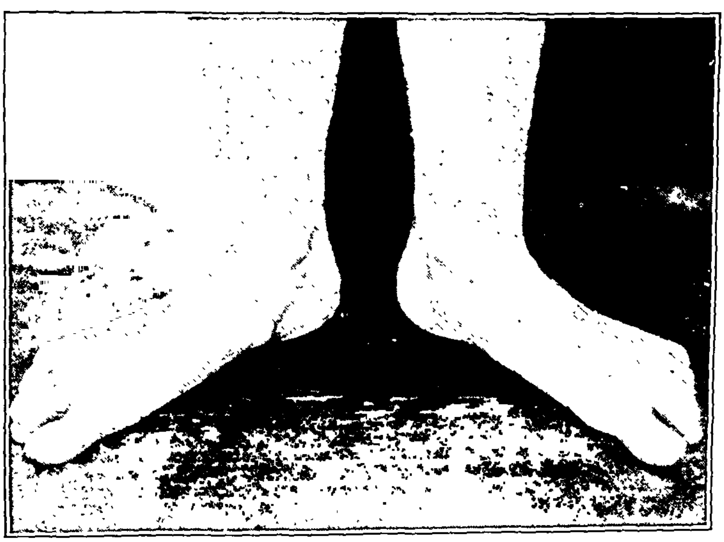

Fig. 1
Shows moderate pronation of the feet, and a large projection over the region of the scaphoid tubercle.

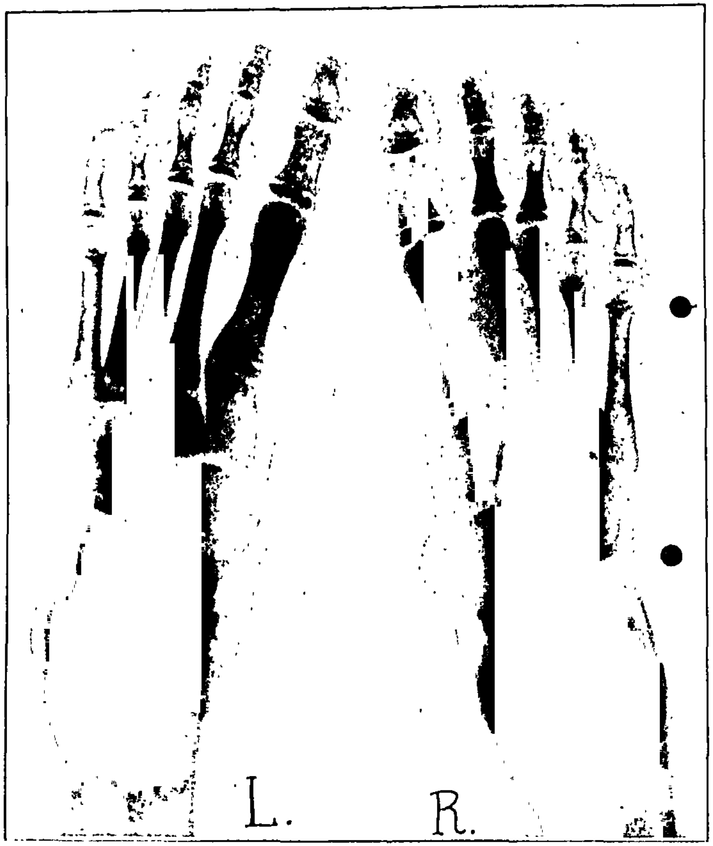

FIG. 2-A

Anterior-posterior view of the same feet showing complete astragaloscaphoid fusion. Note the outline of the soft tissues (retouched) over the projecting medially astragaloscaphoid bones.

FIG. 2-B

Lateral view. Complete astragaloscaphoid fusion of the left foot; there is a suggestion of a joint line (arrow) over the dorsal aspect between the right astragalus and the scaphoid.

FIG. 3-A

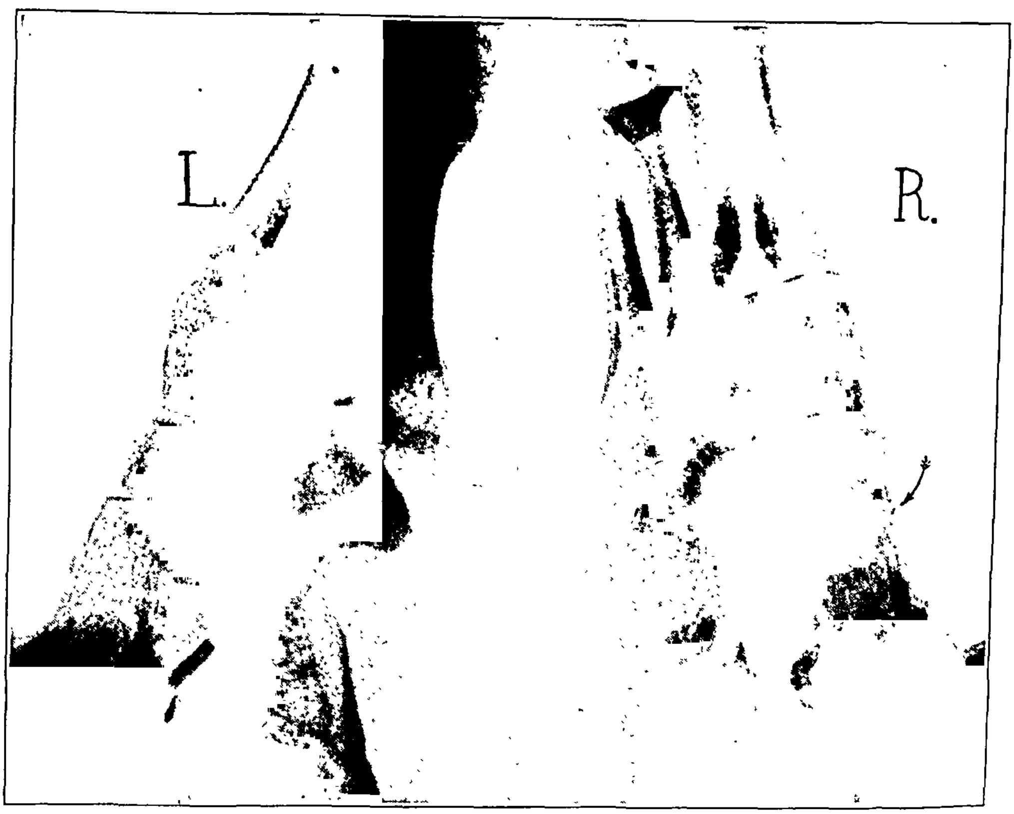

FIG. 3-B

Anterior-posterior and lateral views of feet in a case of traumatic fusion of the right astragaloscaphoid joint. The line of the joint (arrow) can still be made out. Note marked osteo-arthritic changes in the right foot. Large accessory scaphoid is shown on the anterior-posterior view of the left foot.

marked on the right side. Outside of that, all passive and active motions of feet and gait were perfectly normal. The pulsation of both foot arteries were palpable on their usual location. The writer, on first examination, was under the impression that the child had unusually large accessory scaphoids, and only the roentgenograms of the feet (Figs. 2-A and 2-B) revealed the true nature of her condition. The patient was admitted to the Hospital (History No. 29104) and the medial projecting part of the astragaloscaphoid bones was chiseled off. There was some hypermobility in the mid-tarsal joints for a few months following the operation. She wore foot plates for about a year and a half after the operation.

When last seen on January 23, 1932, the patient was quite comfortable; the feet were fairly normal except that a slight pronation was still present. The roentgenographic examination of the feet of both parents and of the patient's brother showed no abnormalities.

The patient's carpal bones were not roentgenographed.

To the best of the writer's knowledge this case is the third recorded where only bilateral congenital fusion of the astragaloscaphoid joint was present, other tarsal joints being normal. After a thorough review of the literature only two similar cases (mentioned above) were found; one reported by Anderson * and the other by Bullitt, the former not quite complete as there were no roentgenograms available in 1879.

The writer recently treated a man about thirty years of age, with the right foot markedly pronated, abducted, and completely flat, due to an injury seven years previously. The roentgenograms (Figs. 3-A and 3-B) showed an almost complete right astragaloscaphoid fusion with marked productive osteo-arthritic changes. This case is included in this paper in order to illustrate the pathological astragaloscaphoid fusion as compared with the congenital.

SUMMARY

1. Congenital fusion of the bones of the feet is rare; the astragaloscaphoid fusion being extremely unusual.
2. Pathological fusion may sometimes simulate a congenital one.
3. One case of bilateral congenital astragaloscaphoid fusion is reported.

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NOTES ON AMPUTATIONS CONNECTED WITH CIRCULATORY DISTURBANCES OF THE EXTREMITIES

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I feel that most workers in the field of the circulatory diseases of the extremities have become convinced that there are two elements, at least, in every circulatory disease:

(1). A spasmodic element under the control of the sympathetic nervous system.

(2). An organic element affecting the vessel walls.

The ratio between the two is rather indeterminate clinically.

It is because of the vasomotor spasm that one is justified in performing a sympathectomy for the amelioration of these diseases. It would seem that the earlier the blood supply to the part was increased the more one could anticipate the return of that part to approximately normal function, and possibly also an arrest of the arterial disease by an increased circulation through the vasa vasorum.

That these two elements are the sole factors involved in any circulatory disease we may not believe, as is well illustrated by a patient on whom we operated several years ago.

. R. B. had a thrombo-angiitis obliterans. This had affected the lower extremities, but subsequently involved both upper extremities. The distal phalanx of the left third finger showed marked discoloration to a definite level just distal to the joint line. This finger was amputated just proximal to the line of demarcation and both the patent phalangeal arteries had to be tied because of their great size. In spite of such a large circulation, the tissue at the site of amputation sloughed for a short distance.

It is an unfortunate thing to amputate a finger or toe and have the sloughing continue back into the foot or hand, necessitating a mid-leg or mid-arm amputation. It is obvious that Nature forms a delicate line of demarcation between life and death and that if surgical interference, such as we have outlined, causes still greater sloughing, then the life or death of adjacent tissues hangs by a slender thread.

It would seem therefore that: (1) in gangrene of the extremities unaccompanied by arterial sclerosis of a degree demonstrable by x-ray, sympathectomy should be done in order to increase to the greatest possible extent the circulation of that quadrant; (2) as the slough that accompanies many of these cases of phalangeal gangrene is exceedingly slow in separating, the slough should be removed as largely as possible, *keeping on the necrotic side of the line of demarcation* and thus in no way interfering with Nature's delicate plan of life.

In our experience, the sloughing is most easily separated by frequent soaking of the extremity in a warm solution of magnesium sulphate. No definite data can be given as to temperature or saline concentration as the

pain accompanying too great heat or too strong a solution is almost unbearable and varies from time to time, and the patient has to regulate these two factors according to his sensations. When the slough is finally separated, the granulating tissues may be gently drawn together by adhesive bands. Suturing is inadvisable for reasons above indicated.

Sloughing involving the dorsum of the foot practically always requires mid-leg amputation. In our experience, mid-thigh amputations are seldom required. However, the case originally referred to in this discussion taught an interesting lesson. One of the lower extremities had to be amputated because of much sloughing of the dorsum of the foot. We anticipated a mid-leg amputation which we did, but were surprised to find that, while all the tissues were healthy in appearance except the anterior tibial muscle, which somewhat resembled a fish, scarcely fifteen drops of blood came from the leg in fifteen minutes without the use of tourniquet, hemostats, or compresses. This condition compelled a mid-thigh amputation, and it revealed that there is a wide difference in the requisite blood supply for life and activity.

THE NORMAL AND PATHOLOGICAL PHYSIOLOGY OF THE NUCLEUS PULPOSUS OF THE INTERVERTEBRAL DISC*

An Anatomical, Clinical, and Experimental Study

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This paper is presented to the members and guests of the American Orthopaedic Association as a careful study and confirmation of the excellent work of Schmorl on the intervertebral disc. The intervertebral disc with its pulpy center is of fundamental importance in the normal and pathological physiology of the spine. An appreciation of the development, anatomy, physiology, and pathology of this structure is necessary for the intelligent interpretation and management of all conditions affecting the spine which we as clinicians are called upon to treat.

THE ANATOMY OF THE INTERVERTEBRAL DISC

Anatomists have described the intervertebral disc as far back as Vesalius [1] in 1555. It remained however for von Luschka [2] to give an accurate description of its structure and embryology. Bardeen [3], in his studies of the development of the spine, postulated as to its physiological importance. No clinical nor pathological observations were made until Schmorl[4], a pathologist of Dresden, described the frequent prolapses of the disc into the adjacent vertebral bodies.

THE DEVELOPMENT OF THE SPINE

The physiological and pathological significance of the intervertebral disc can not be well appreciated without some knowledge of the developmental and structural anatomy. This was first carefully reported by von Luschka [2] who traced the development of the notochord and the formation of the intervertebral disc in 1858. Kölliker [5], in 1859, noted that the central portion of the intervertebral disc in a one-year-old child contained residual notochord cells. In 1879, Löwe [6] found that the entire nucleus pulposus of the rat was formed by the notochord. Leboucq [7], in 1880, believed, from his studies of human and other mammalian embryos, that the notochord tissue was practically destroyed long before birth. This we know is not true. Virchow [8] (1857) and Dursy [9] (1869) suggested that the nucleus pulposus was formed by degeneration of the annulus fibrosus fibers. Bardeen, in 1905, and Williams [10], in 1908, wrote extensive studies of the development of the spine, and more recently

*Read before the American Orthopaedic Association, at Toronto, Canada, June 18, 1932.

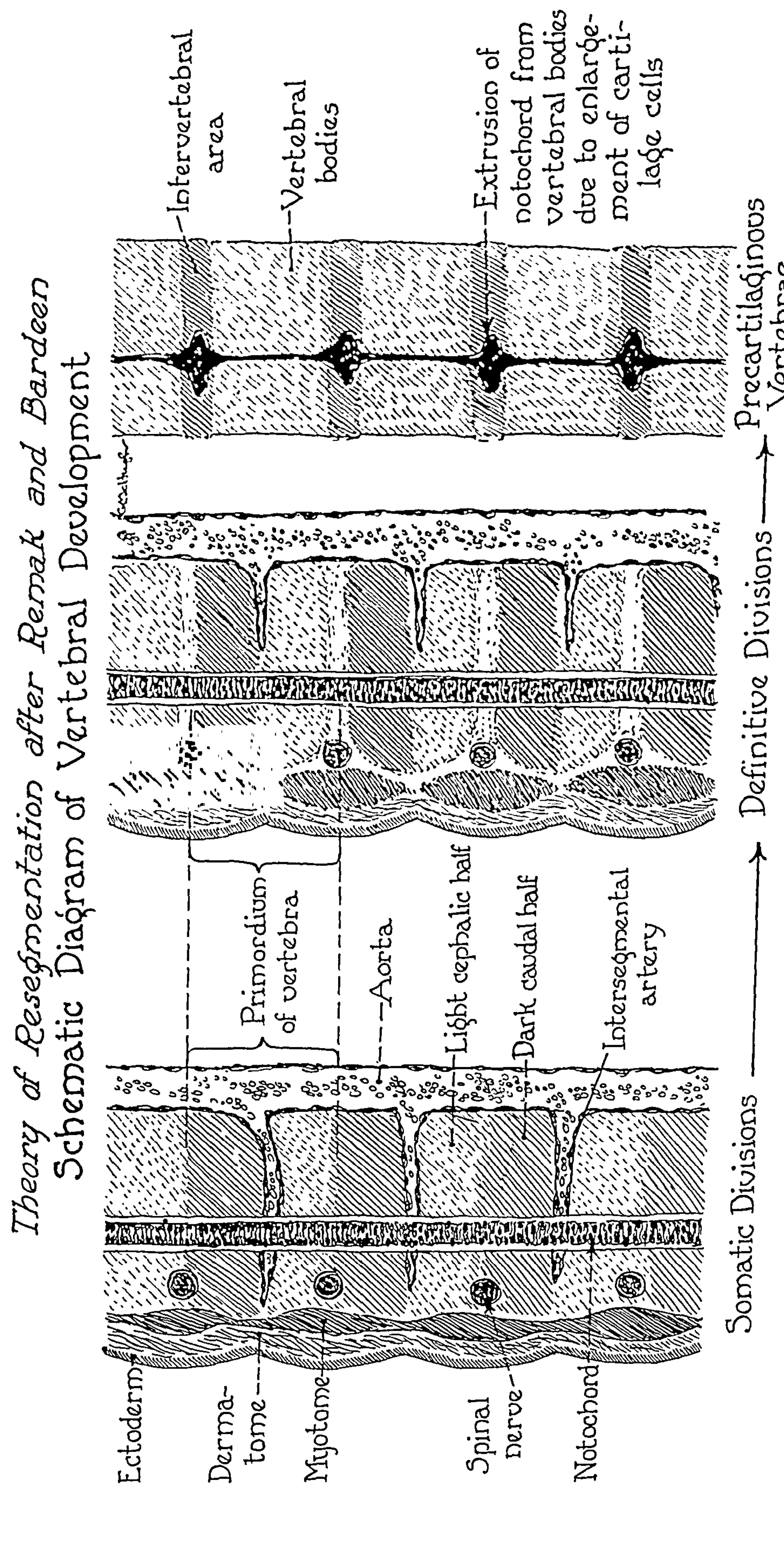

Fig. 1

A diagrammatic sketch illustrating the vertebral development after the theory of Ramak and Bardeen.

Schmorl, Calvé and Galland, and Beadle have made additions to this subject.

The definite origin of the notochord is not well established. Kollman [11], Bardeen, and Minot [12] state that at a very early period of the embryo there is a thickening of the entoderm in the mid-sagittal plane known as the chordal plate. This ridge of cells in a human embryo of two and eleven-hundredths millimeters was described by Kollman. The chordal plate is gradually pinched off from the entoderm and is then known as the notochord.

A migration of mesenchymal cells occurs from the sclerotomes to surround the notochord (Figs. 1 and 2).* Remak [13] and Bardeen believe these cells arrange themselves in a segmented column in accordance with the primitive segmentation of the embryo, each vertebral segment or protovertebra being marked off by the entrance of the intersegmental artery. Bardeen believes that each protovertebra develops a condensed caudal and a light cephalic half and that the definitive vertebra is then formed by the union of the condensed caudal half of the protovertebra above with the light cephalic half of the protovertebra below (Fig. 3). Williams, however, does not accept this theory of resegmentation. He states that, following the migration of the mesenchymal cells about the notochord, there is no period of condensation and formation of protovertebrae. He concludes from his studies that the segmentation of the vertebrae is entirely definitive. The early demarcation of the vertebrae is the result of differential growth and not condensation. The mesenchymal cells, composed almost entirely of nucleus, begin to add cytoplasm rapidly in the region of the vertebral bodies, while little change is noted in the intervertebral area. Thus the intervertebral regions, composed of nuclear material, appear condensed.

Our studies lead us to the following conclusions concerning this phase of the development of the spine. We differ somewhat with, yet bring together and confirm, the views of both Bardeen and Williams. The mesenchymal cells of the schlerotome migrate to surround the notochord. These cells form a segmented column, the segments of which are marked off above and below by the entrance of the intersegmental arteries. Each segment shows a massing of these cells laterally into two groups,—a light cephalic mass and a darker caudal mass. The cells nearer the intersegmental arteries receive more nutrition than those farther removed, and hence are more rapid in their differentiation. Therefore the cephalic mass of the segment below and the caudal portion of the caudal mass of the segment above rapidly add cytoplasm, merge, and become the anlage of the vertebral body. The cranial portion of the caudal mass, being the

* The illustrations as prepared by the author showed the exact magnification of most of the photomicrographs. In order to preserve the author's grouping, in having the half-tones made it has been necessary to reduce the illustrations to conform to the size of *The Journal* page. With each legend has been included a note showing the reduction of the illustration, as published, from the original illustration prepared by the author. This reduction should be taken into consideration in determining the magnification of the photomicrograph.

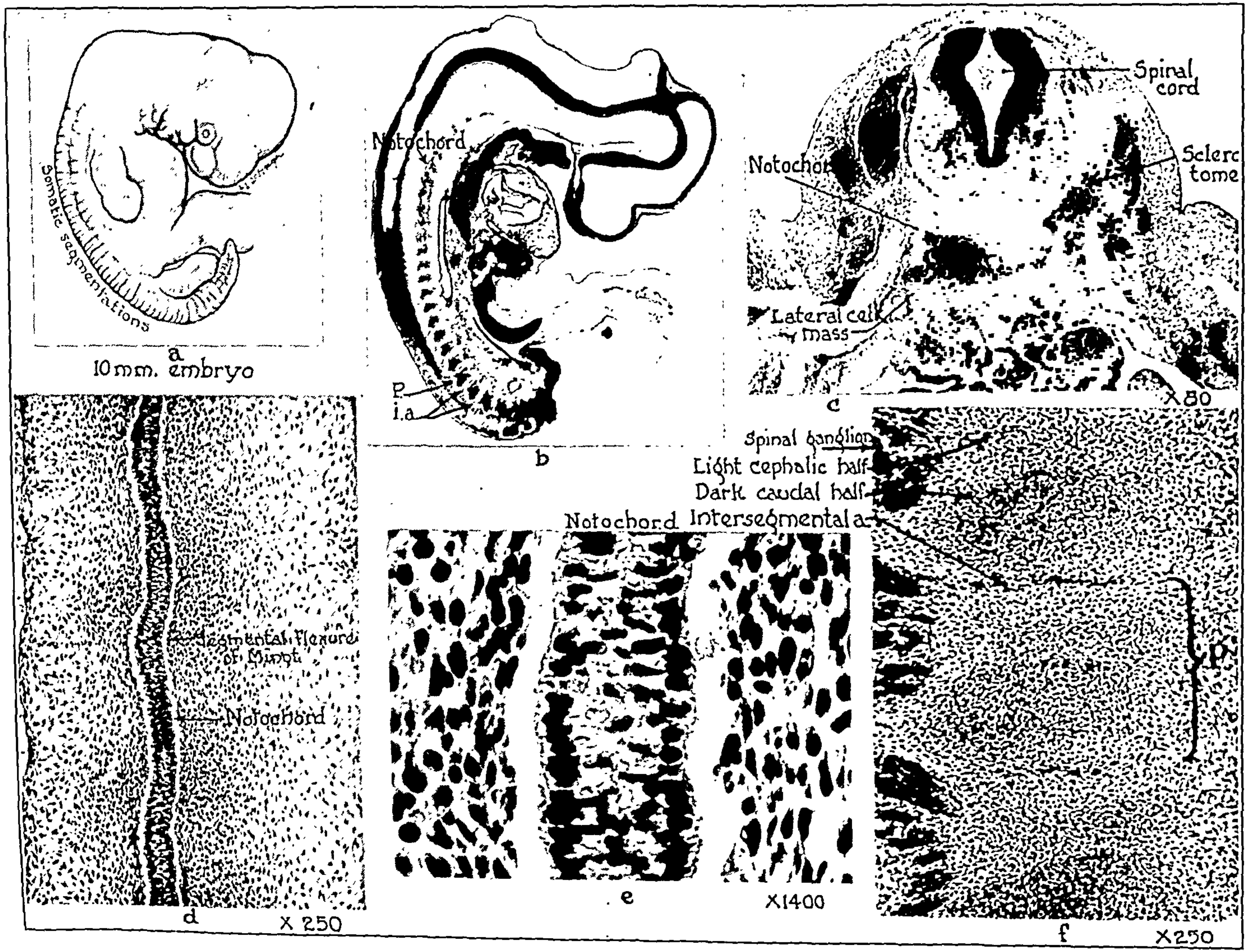

FIG. 2

A human embryo of ten-millimeters (five weeks). (Two-fifths size of original illustration.)

a. Lateral view of specimen showing somatic segmentation.

b. Mid-sagittal section of specimen. *P*. primitive segment or protovertebra; *i.a.* intersegmental artery. Notochord with segmental flexures of Minot. For detailed structure of notochord see sections *d*. and *e*. The primitive segmentation (protovertebrae) of Bardeen is well demonstrated in the caudal portion of this specimen with advancement toward the definitive stage cephalically. These segments are marked off above and below by the intersegmental arteries. (See section *f*.) Note the light cephalic half and dark caudal half of each protovertebra and the beginning differentiation and addition of cytoplasm of these two areas in the region of the intersegmental artery.

c. Mid-dorsal cross section. Note the migration of the mesenchymal cells

FIG. 2 (*Continued*)

from the schlerotome to surround the notochord. These cells are massed laterally, leaving the true mid-sagittal plane relatively less dense; this is apparent in section *d*. which is cut in the true mid-sagittal plane.

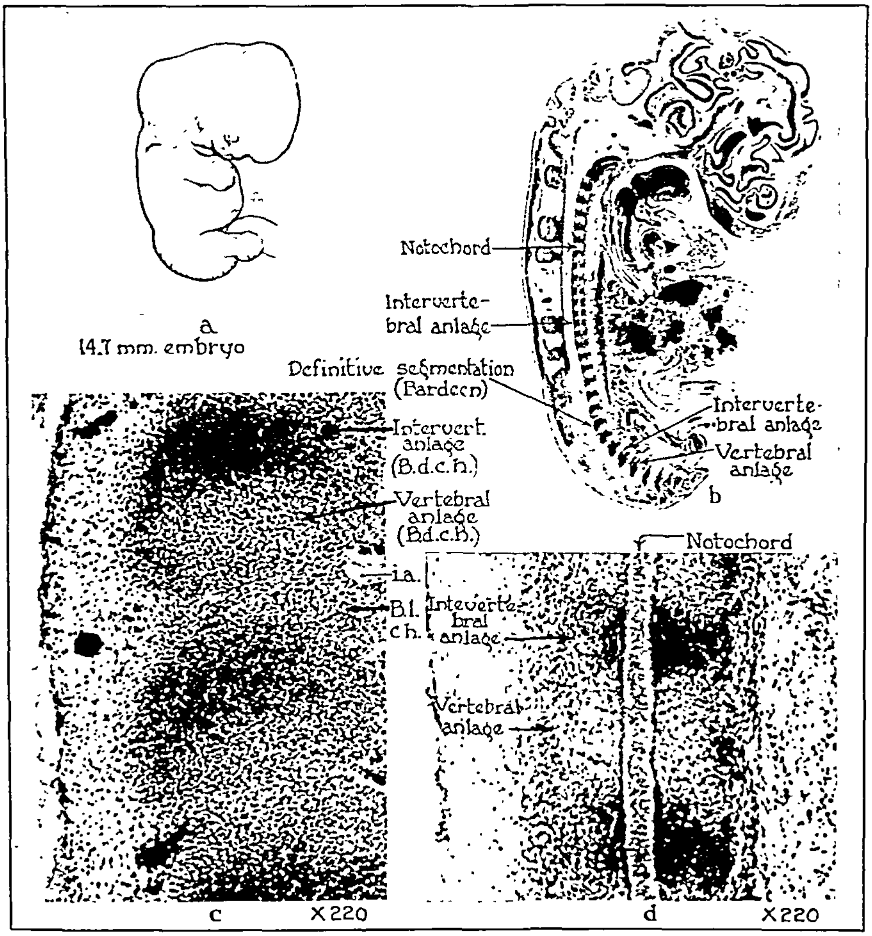

FIG. 3

A human embryo of fourteen and seven-tenths millimeters (six-and-one-half-weeks). (Two-fifths size of original illustration.)

a. Lateral view of specimen.

b. Mid-sagittal section of specimen. The notochord displays little change from that seen in the five-week embryo of Fig. 2. The vertebral development, however, shows definite advance toward the definitive form. Here again we note that the cells of the light cephalic half of the protovertebra below and those of the caudal part of the dark caudal half of the protovertebra above (or those cells surrounding the intersegmental artery) are adding cytoplasm, merging and forming the definitive vertebral anlage. The cells of the cephalic portion of the dark caudal half remain as a dense nuclear mass, the intervertebral disc anlage. The higher magnifications in *c*. and *d*. bring this out more clearly. *B.d.c.h.* the dark caudal half of the protovertebra after Bardeen; *B.l.c.h.* the light cephalic half of the protovertebra after Bardeen; *i.a.* intersegmental artery.

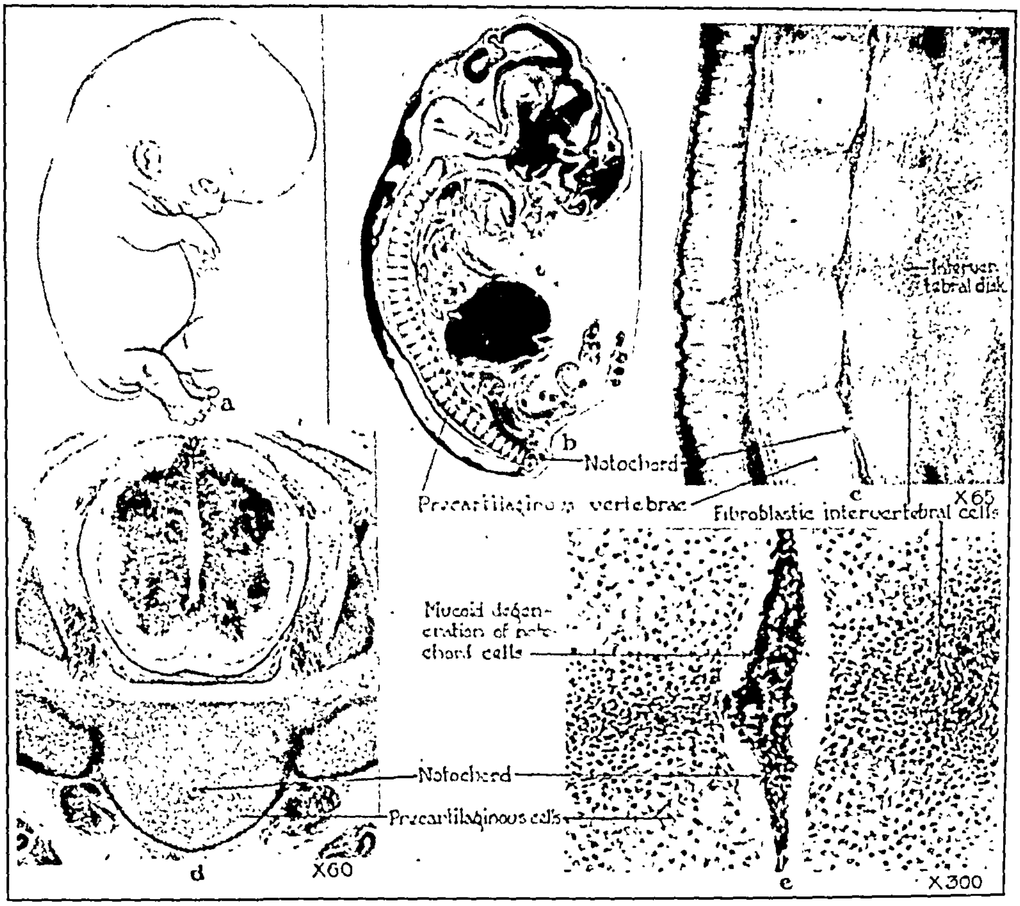

FIG. 4

A human embryo of twenty-one millimeters (seven and one-half weeks). (One-third size of original illustration.)

a. Lateral view of specimen.

b. Mid-sagittal section of specimen. The cells of the vertebral bodies contain a large amount of cytoplasm, but as yet there is no intercellular matrix. We, therefore, speak of this as the precartilaginous stage. See sections *c.*, *d.*, and *e.* The intervertebral regions have shown relatively less histological change, the cells are, however, elongating into fibroblastic type. The notochord cells are being squeezed from the vertebral into the intervertebral regions and show mucoid material both intracellular and extracellular.

d. A mid-dorsal cross section traversing vertebral body. The notochord may be seen as a small area in the center of the body.

furthest removed from the source of nutrition (the intersegmental artery), remains undifferentiated as the anlage of the intervertebral disc. It is of interest that this portion of the spine remains avascular throughout developmental and adult life.

With the rapid addition of cytoplasm to the cells of the vertebral regions, there occurs a marked difference in the pressure exerted upon the notochord. The cells of this structure begin to be extruded into the intervertebral regions where the pressure is less (Fig. 4). Mucoid degeneration of the notochord cells appears. This mucoid material may be found both extracellular and within the cells as vesicles. The cells of the intervertebral region now begin to differentiate into an elongated fibroblastic type and are arranged along a vertical axis, attaching above and below to the vertebral bodies.

In the embryo of ten weeks (Fig. 5), the cells of the vertebral bodies have developed into typical cartilage cells, and ossification centers are now present. The cells of the notochord have been entirely extruded from the vertebral region and are now confined to the central portion of the intervertebral disc. The old site of the notochord in the vertebral bodies is marked only by a streak of mucoid material. Centrally this is entirely obliterated by the ossification centers. We may speak, henceforth, of the notochord material as the nucleus pulposus and of the surrounding fibrocartilage as the annulus fibrosus. The fibers of the annulus fibrosus are becoming better defined and may be seen to be attached centrally above and below to the cartilaginous vertebral bodies immediately about the old notochord site. They are bulged out laterally in the mid-portion of the disc by the enlarging nucleus pulposus. Thus the nucleus pulposus material does not come in direct contact with the adjacent surfaces of the vertebral bodies, but is separated by a layer of fibrocartilage arising from the intervertebral disc substance. This is an important

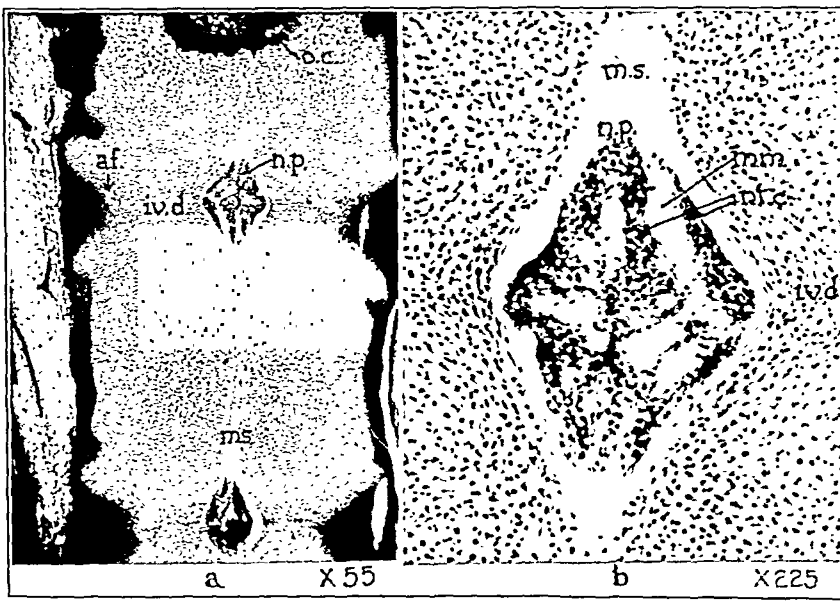

Fig. 5

A human embryo of fifty-seven millimeters (ten weeks). (One-half size of original illustration.)

a.f. annulus fibrosus; *n.p.* nucleus pulposus; *i.v.d.* intervertebral disc; *o.c.* ossification center; *m.s.* mucoid streak remnant of the notochord; *m.m.* mucoid material; *nt.c.* notochord cells.

The notochord cells are entirely extruded from the vertebral into the intervertebral region. Only a mucoid streak marks the old site of the notochord in the vertebrae. Ossification centers are now forming in the vertebral bodies and these entirely destroy all traces of the notochord. The fibroblastic intervertebral cells are bulged out centrally, though they maintain their original site of attachment to the cartilaginous vertebral bodies. Thus they form a fibrocartilaginous envelope separating the nucleus pulposus from direct contact with the cartilage of the vertebral bodies.

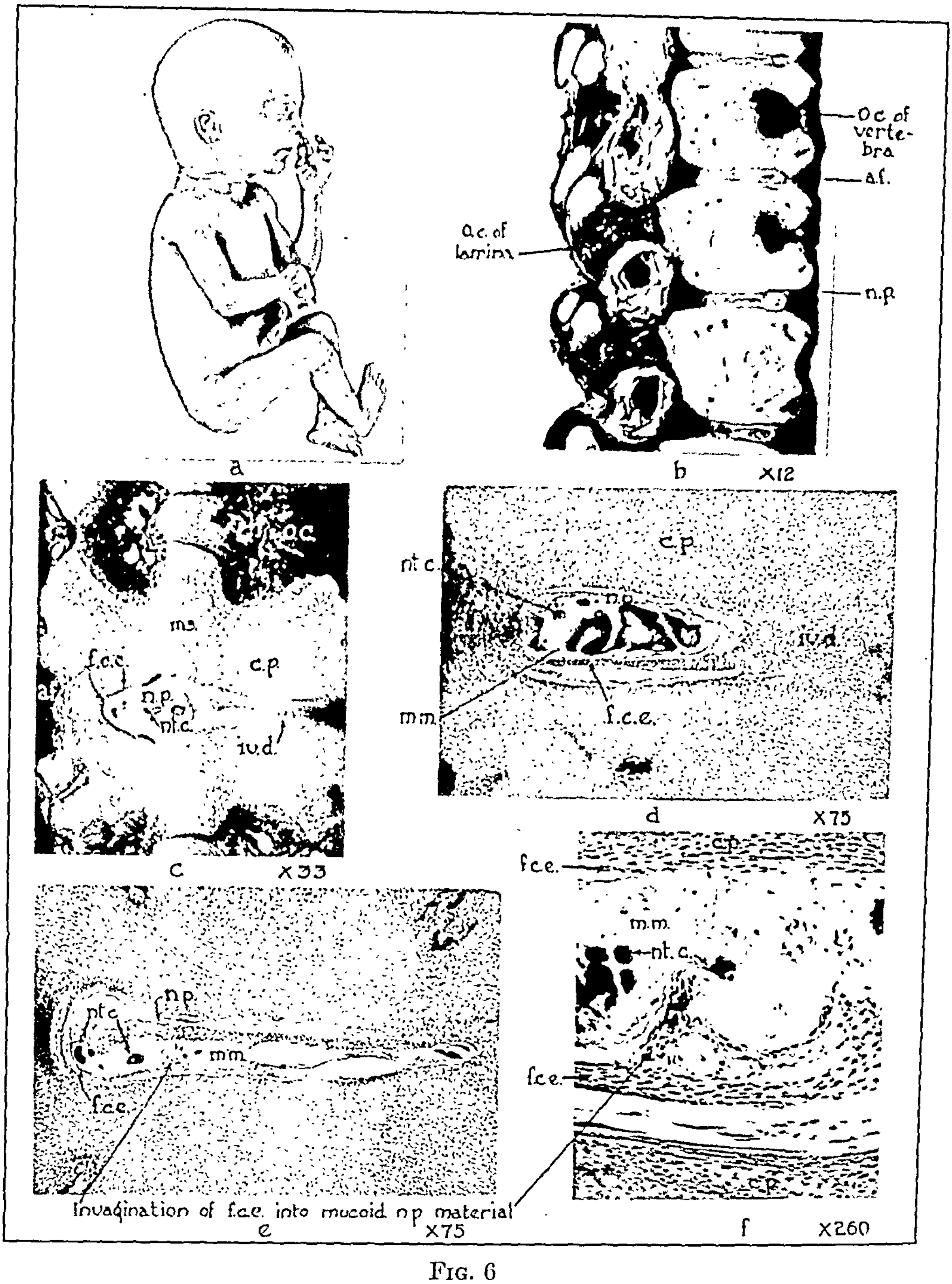

Fig. 6

A human embryo of one hundred and fifty-seven millimeters (eighteen weeks). (One-third size of original illustration.)

a.f. annulus fibrosus; *n.p.* nucleus pulposus; *o.c.* ossification center; *m.s.* mucoid streak; *f.c.e.* fibrocartilage envelope; *i.v.d.* intervertebral disc; *nt.c.* notochord cells; *m.m.* mucoid material; *c.p.* cartilage plate.

a. Lateral view of specimen.

b. Mid-sagittal section of specimen. The intervertebral discs in this specimen show a definitely fibrous annulus fibrosus surrounding a large mucoid nucleus pulposus. The fibers of the annulus fibrosus immediately surrounding the nucleus pulposus are clear and sharply staining, and maintain their original attachment to the cartilage plate around the mucoid streak marking the old site of the notochord. (See section *c.*) They form thereby a fibrous or fibrocartilaginous envelope about the nucleus pulposus, separating this body from direct contact with the cartilage plate. Invaginations from this fibrocartilage envelope are seen invading the mucoid nucleus pulposus material, sections *e.* and *f.*

d. An estimate of the large amount of notochord cells still present may be gathered from this section.

observation in connection with the later development of the nucleus pulposus.

In the embryo of eighteen weeks (Fig. 6), the mucoid tract seen in Figure 4 is still present. A still greater increase in size and mucoid content of the nucleus pulposus is noted. The fibrocartilage envelope shows in its central portion invaginations invading the mucoid material. This, we believe, with Robin [14], is the origin of the fibrous tissue found in such quantity in the adult nucleus pulposus. We also call attention to the clearly outlined and sharply stained annulus fibrosus fibers which immediately surround the nucleus pulposus material. Demonstration of these fibers in the eighteen-week embryo disproves the theory of Dursy and Virchow that the degeneration of the annulus fibrosus fibers is the chief source of the nucleus pulposus material. It should also be noted in this eighteen-week embryo that more actual notochord material is present in

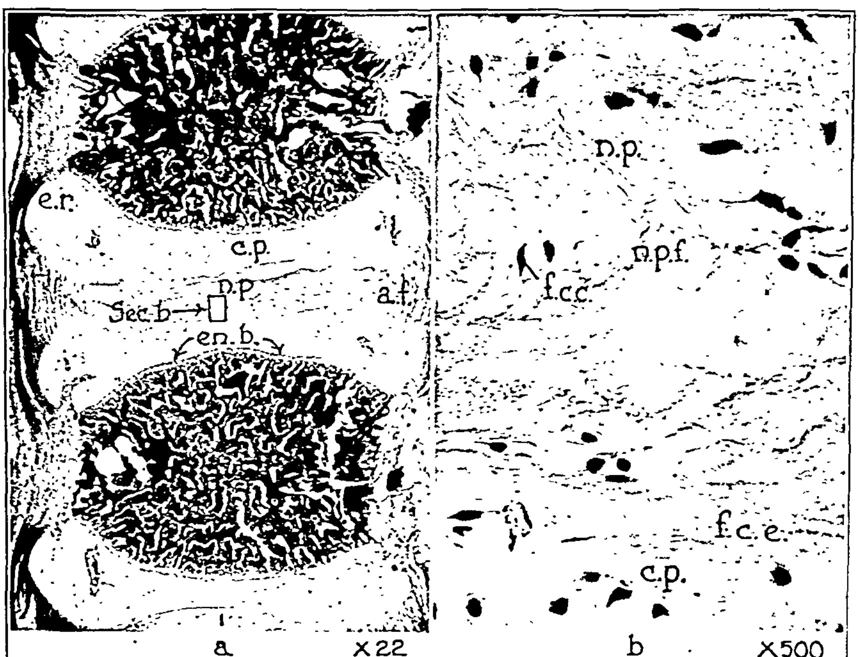

Fig. 7

A full-term human foetus. (One-half size of original illustration.)

a.f. annulus fibrosus; *n.p.* nucleus pulposus; *c.p.* cartilage plate; *e.r.* epiphyseal ring; *en.b.* enchondral bone formation; *f.c.e.* fibrocartilage envelope; *f.c.c.* fibrocartilage cells; *n.p.f.* nucleus pulposus fibers.

a. Mid-sagittal section of spine, through the first and second lumbar vertebrae and intervening disc. Note the growth zone where enchondral bone formation is extending across the entire bone end, both in the region of the epiphyseal ring and cartilage plate proper.

b. A high magnification of the area where the nucleus pulposus gradually merges into the cartilage plate. This gradual merging is the result of the extension of the fibers from the fibrocartilage portion of the cartilage plate, the fibrocartilage envelope, into the nucleus pulposus. The cartilage plate is formed of a hyaline cartilage adjacent to the bone and a fibrocartilage adjacent to the intervertebral disc.

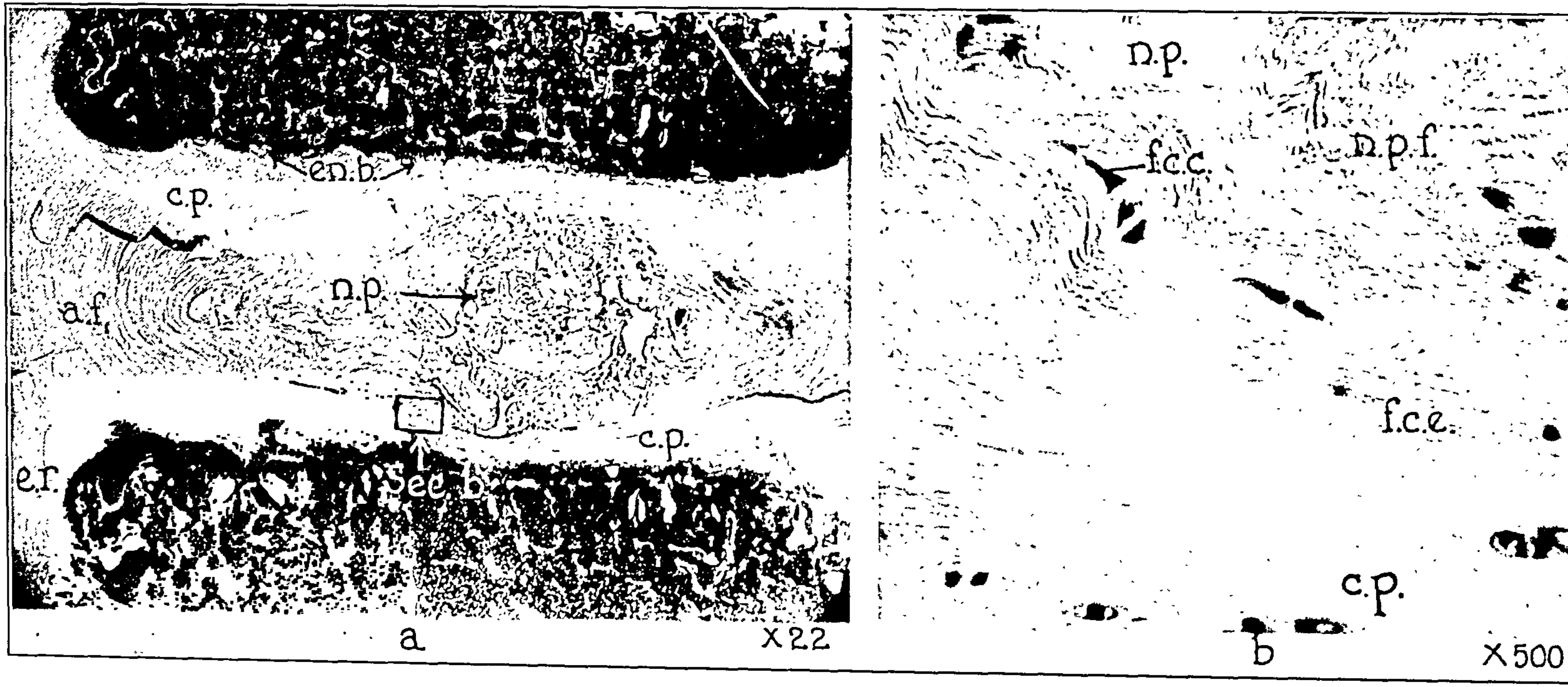

Fig. 8

From an eight-year-old child. (Three-fifths size of original illustration.)

a.f. annulus fibrosus; *n.p.* nucleus pulposus; *c.p.* cartilage plate; *e.r.* epiphyseal ring; *en.b.* enchondral bone formation; *f.c.e.* fibrocartilage envelope; *f.c.c.* fibrocartilage cells; *n.p.f.* nucleus pulposus fibers.

a. A mid-sagittal section through the first and second lumbar vertebrae and intervening disc. The enchondral bone formation extends across the entire bone end. The overlapping epiphyseal ring is better demarcated than in Fig. 7.

b. The hyaline and fibrocartilage portions of the cartilage plate and the fibrocartilage extensions into the nucleus pulposus are likewise better illustrated than in Fig. 7.

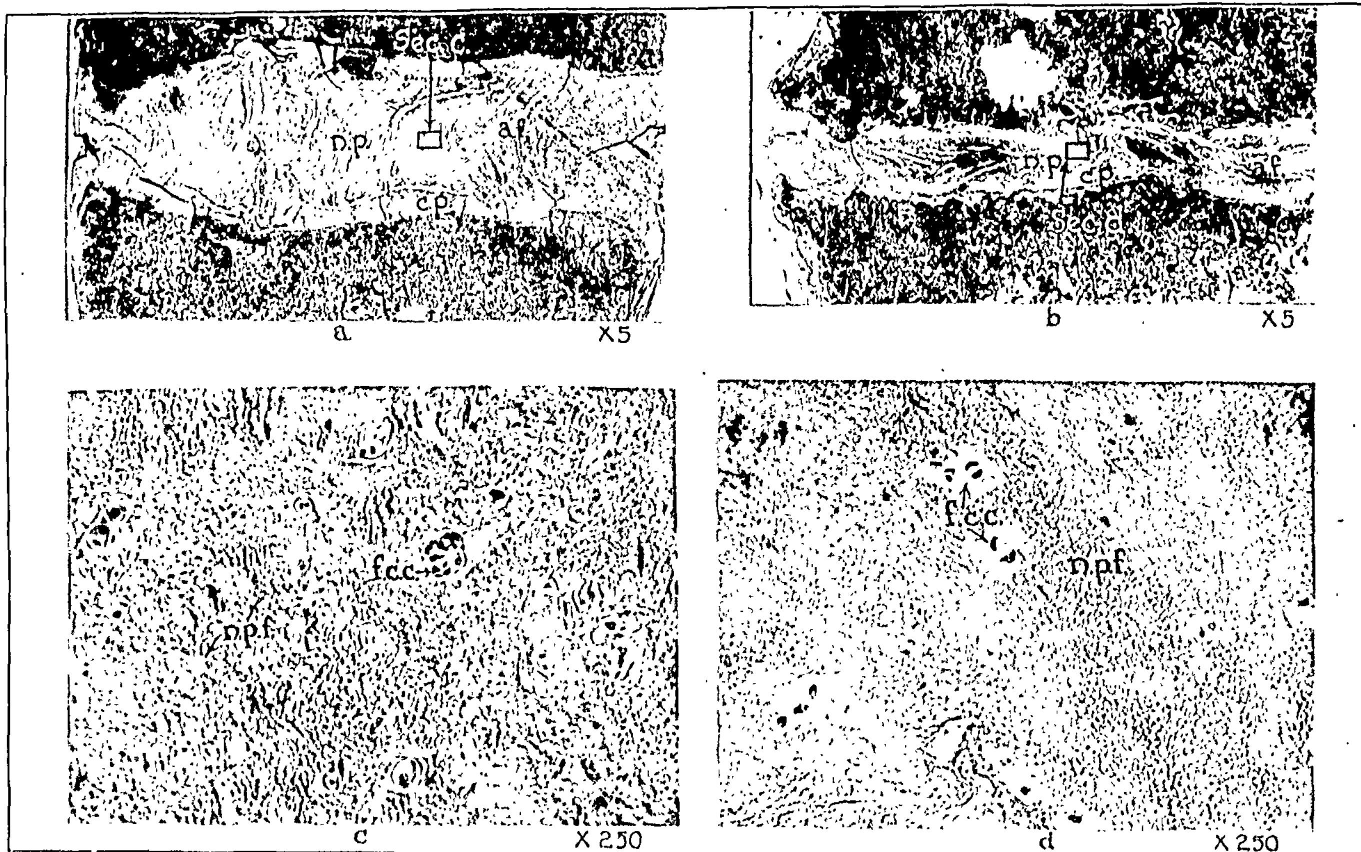

FIG. 9

Mid-sagittal sections through the intervertebral discs of a sixty-eight-year human adult. (One-half size of original illustrations.) Note the marked increase of the fibrous element at the expense of the mucoid matrix.

a.f. annulus fibrosus; *n.p.* nucleus pulposus; *c.p.* cartilage plate; *n.p.f.* nucleus pulposus fibers; *f.c.c.* fibrocartilage cells.

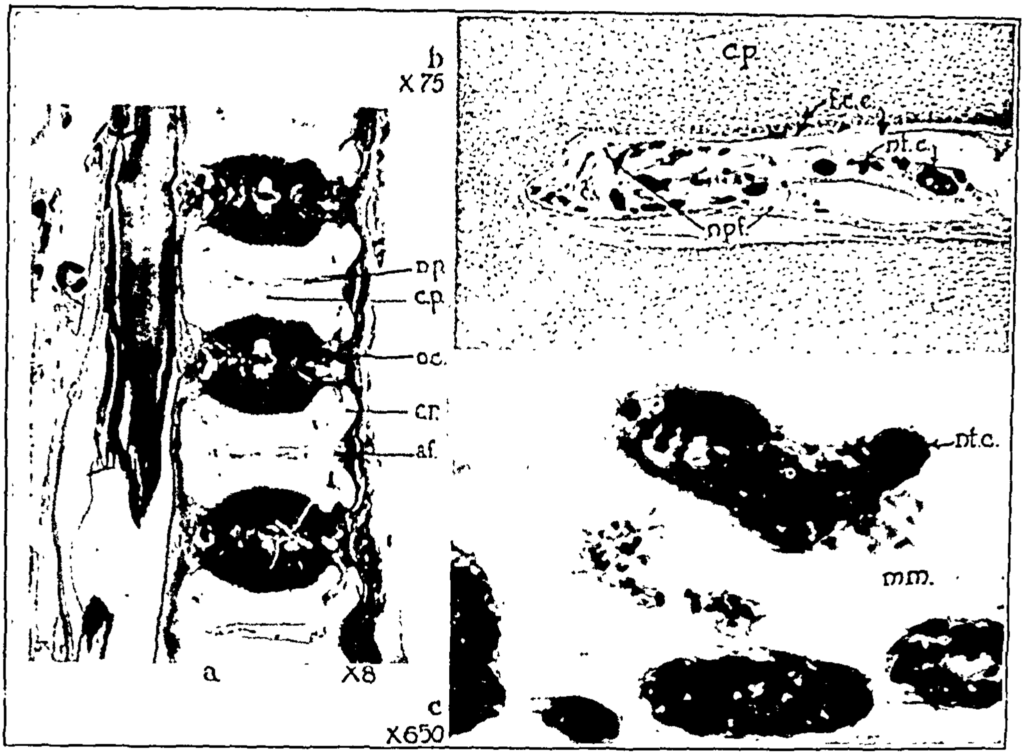

FIG. 10

A human embryo of two hundred millimeters (twenty-four weeks). (Two-fifths size of original illustration.)

n.p. nucleus pulposus; *a.f.* annulus fibrosus; *c.p.* cartilage plate; *o.c.* ossification center; *c.r.* epiphyseal ring; *n.p.f.* nucleus pulposus fibers; *nt.c.* notochord cells; *f.c.e.* fibrocartilage envelope; *m.m.* mucoid material forming matrix of nucleus pulposus.

a. A mid-sagittal section through the twelfth dorsal, first and second lumbar vertebrae. The ossification centers now separate the cartilaginous vertebral bodies into two cartilage plates covering the adjacent surfaces. The enchondral bone formation is seen to extend across the entire bone end.

b. and *c.* Are higher magnifications of the intervertebral disc and nucleus pulposus. They show the surrounding fibrocartilage envelope, expansions of which are invading the mucoid nucleus pulposus.

one intervertebral disc than could be found in the entire notochord of the embryo of seven and one-half weeks, in which mucoid degeneration was first noted. We feel, therefore, quite certain that, at least up to birth, the notochord tissue serves as the chief source of the nucleus pulposus material, and that the interspersed fibrous material and cartilage cells are derived from the fibrocartilage envelope. After birth the notochord cells disappear, though remnants may be found even in the adult nucleus pulposus. The growth of this body is now chiefly by proliferation of the

FIG. 11

The epiphyseal ring development. (Two-thirds size of original illustration.)

a.f. annulus fibrosus; *c.r.* epiphyseal ring; *en.b.* enchondral bone formation; *c.p.* cartilage plate; *cal.* calcification of cartilage plate; *b.t.* bone trabeculae; *b.m.* bone marrow.

a. A section through the epiphyseal ring region of a fifteen-year-old girl. Note the ossification center preceded by a zone of calcification obliterating the cartilage plate. This is quite comparable to the end stage of epiphyseal growth in any long bone.

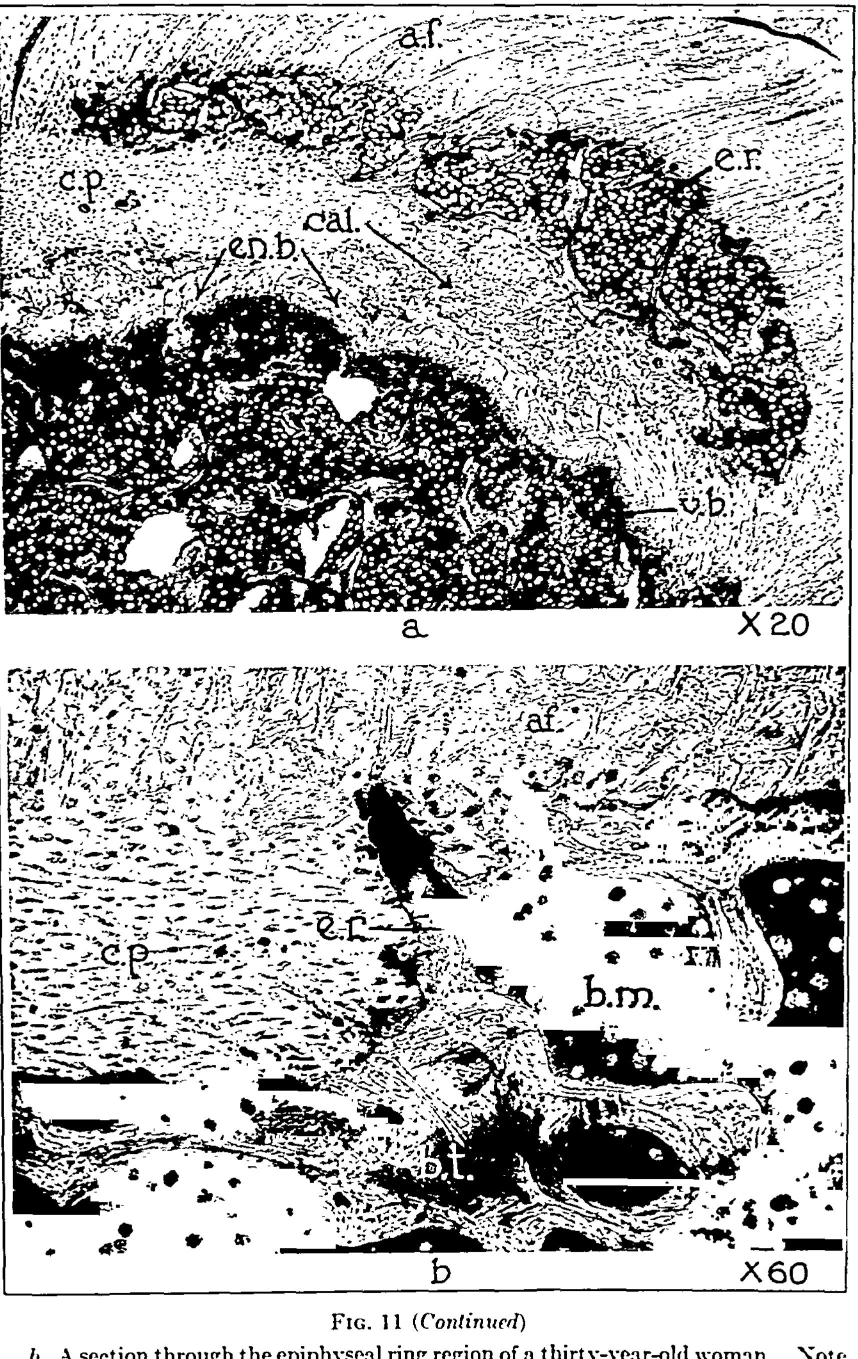

FIG. 11 (*Continued*)

b. A section through the epiphyseal ring region of a thirty-year-old woman. Note the complete fusion of the epiphyseal ring to the vertebral body. The cartilage plate does not fray out into the annulus fibrosus, but ends abruptly by abutting the bony epiphyseal ring. The annulus fibrosus fibers do attach to the cartilage plate, but only to the fibrocartilaginous part which was derived from the fibrocartilage envelope. Enchondral bone growth has disappeared both in the subepiphyseal ring and subcartilage plate regions.

fibrous element. These fibers may always be traced to their attachment to the fibrocartilage envelope, although this structure becomes intimately blended with the cartilage plate covering the adjacent surfaces of the vertebrae.

In the full-term foetus (Fig. 7) and fourteen-months-old child, fine strands of fibrocartilage are becoming more numerous in the mucoid nucleus pulposus. In the four-year-old child, the fibrous element is becoming quite prominent and frequent cartilage cells are encountered. Notochord cells are now difficult to find. In the eight-year and twelve-year discs (Fig. 8), the nucleus pulposus is made up almost completely of loose fibrocartilage with abundant gelatinous matrix. This process of maturation with fibrocartilage replacement of the gelatinous mucoid material progresses continually throughout life, until the senile intervertebral disc (Fig. 9) is composed almost entirely of a dense irregularly arranged fibrocartilage with an entire loss of its gelatinous character and resiliency. There has been noted independently by us and by Püschel [15], associated with Schmorl in Dresden, a progressive loss in water content of the intervertebral disc substance as age advances. Püschel reports that, in the full-term foetus, the water content of the nucleus pulposus is about eighty-eight per cent.; at eighteen years of age, this falls to eighty per cent.; and at seventy-seven years, to sixty-nine per cent. Our determinations compare very closely with these in that in the full-term foetus the water content of the nucleus pulposus was found to be eighty-eight per cent.; at twelve years, eighty per cent.; and at seventy-two years, seventy per cent.

In the embryo of twenty-four weeks (Fig. 10), the ossification center of the vertebral bodies divides the cartilaginous anlage of the vertebra into two separate plates covering the adjacent or intervertebral surfaces. It is from the central surfaces of these cartilaginous plates that osseous growth by enchondral bone formation is continued until full growth is obtained. This period is very variable and ends at between seventeen and twenty years of age in the female and at twenty to twenty-five years in the male. This cartilage plate is entirely comparable to the epiphysis of long bones (Fig. 11). On the surface of the cartilage plate adjacent to the osseous center is found a typical columnar arrangement of cells, calcification of the intervening matrix, and new bone formation. This process extends across the entire superior and inferior surfaces of the vertebral bodies and is not absent at the periphery in the region of the epiphyseal ring. At the periphery the cartilage plate overlaps the anterior and lateral borders of the osseous vertebrae. It is this portion of the cartilage plate that Schmorl and Beadle [16] attempt to separate as a peculiar and different structure, though obviously of the same genetic origin. In opposition to the views of Schmorl and Beadle, we believe that the only point of variance of this cartilage plate and any long bone epiphysis is that the final ossification (Fig. 11) does not extend completely across the bone end, but is confined to the peripheral portion, forming an incomplete bony ring

(epiphyseal ring). The remainder persists as the cartilage plate intimately blended with the fibrocartilage envelope previously described. It covers the bony vertebral surface, separating this from the nucleus pulposus, and gives attachment to the fibers of the nucleus pulposus and annulus fibrosus. The enchondral bone growth ceases simultaneously in the subcartilage plate region and in the subepiphyseal ring region when

FIG. 12

a. A roentgenogram of the dorsal spine of an eight-year-old girl. Note the rarefaction about the epiphyseal ring region of the eighth dorsal vertebra.
b. A roentgenogram of the same region at the age of sixteen. Note the prolapse of the nucleus pulposus material into the adjacent vertebral bodies, the narrowing of the involved discs, and the marginal lipping and the round-back deformity.

bony union of the epiphyseal ring and vertebral body occurs. After fusion of the epiphyseal ring, the cartilage plate ends abruptly in the anterior and lateral regions by abutting this bony ring (Fig. 11). It does not fray out and become lost as Beadle would have us believe. The fraying out is merely the continuance of the annulus fibrosus and nucleus pulposus fibers into the fibrocartilaginous portion of the cartilage plate. Anteriorly and laterally the bony epiphysis serves this same function as the base of attachment of these fibers. As further evidence of the indivisibility of these two structures, we present the following case (Fig. 12):

A girl, eight years of age, was seen in 1924 with the complaint of backache, localized to the region of the eighth dorsal vertebra. An x-ray examination of this region revealed disturbance and rarefaction about the epiphyseal ring of the eighth dorsal vertebra. In 1932 roentgenograms were again taken of this patient, revealing a typical kyphosis dorsalis juvenilis with degeneration of the cartilage plate and prolapse of the nucleus pulposus material into the adjacent vertebral body. This involvement was also localized to the eighth dorsal vertebra. Thus disturbance of the cartilage plate was noted, first in the region of the epiphyseal ring and later in the cartilage plate proper.

Mau [17] also uses this type of case to refute Schmorl's theory that the epiphyseal ring exists as a structure unrelated to the cartilage plate.

THE ADULT INTERVERTEBRAL DISC

Because of the progressive changes throughout life occurring in the intervertebral disc, no normal can be accurately described unless the age be specified. It may be said here however that, in discs unaffected by pathological processes, the nucleus pulposus retains its semigelatinous consistency even beyond the fifth or sixth decade, and on sectioning the fresh specimen it is partially extruded by the elasticity of the annulus fibrosus.

We will describe as a normal intervertebral disc one in the third decade (Fig. 13). The adjacent vertebral surfaces are entirely covered by a thin layer of cortical bone. This is quite compact in the central area over the region of the nucleus pulposus, while peripherally it becomes more porous. The outer rim is raised and is the fused epiphyseal ring. Over this cortical bone lies the cartilage plate. This is composed of hyaline cartilage which ends abruptly in the anterior and lateral regions by abutting the bony epiphyseal ring. Intimately blended with this on its intervertebral surface is a layer of fibrocartilage which gives attachment to the fibers of the annulus fibrosus and nucleus pulposus. The annulus fibrosus is a dense fibrocartilage, firmly attached to the adjacent vertebrae, and forming a strong but elastic envelope of the fibrogelatinous, incompressible nucleus pulposus. The adult intervertebral disc contains neither blood vessels nor nerves. The nutrition of this body is carried entirely by the lymph stream. Jung and Brunschwig [18], after careful study, found nerve fibers only in the anterior and lateral longitudinal ligaments.

THE FUNCTION OF THE INTERVERTEBRAL DISC

The nucleus pulposus is a fibrogelatinous material subject to the laws of fluids. It may be considered, therefore, incompressible and confined to its normal shape and position by the strong and elastic annulus fibrosus. It is the elastic tension of the latter which extrudes the nucleus pulposus material when the disc is sectioned. The pressure of the nucleus pulposus material in the living organism is not only the result of the elastic tension of the annulus fibrosus, but also that of muscle tone and static forces transmitted from one vertebral body to the next. The proper function of the nucleus pulposus, therefore, depends upon the integrity of its limiting structures, *viz.*, the cartilage plates above and below and the surrounding annulus fibrosus. The primary hypothesis of incompressibility of the nucleus pulposus demands that any compression of the intervertebral disc must result from the change of shape of the nucleus pulposus at the expense of the elastic annulus fibrosus. The amount of compression of the intervertebral disc will, therefore, depend upon the elasticity and strength of this structure. From observation of this fibrocartilaginous ring, we may postulate that only minor changes may take place under the forces to which it is exposed. These changes, however, are sufficient to give the intervertebral disc enough resiliency to absorb the

shocks transmitted along the vertebral column. The incompressibility of this portion of the intervertebral disc lends to it the function of transmitting the static and muscular forces from one vertebral body to the next and establishes it as the axis of motion upon which each vertebral body must work (Fig. 14).

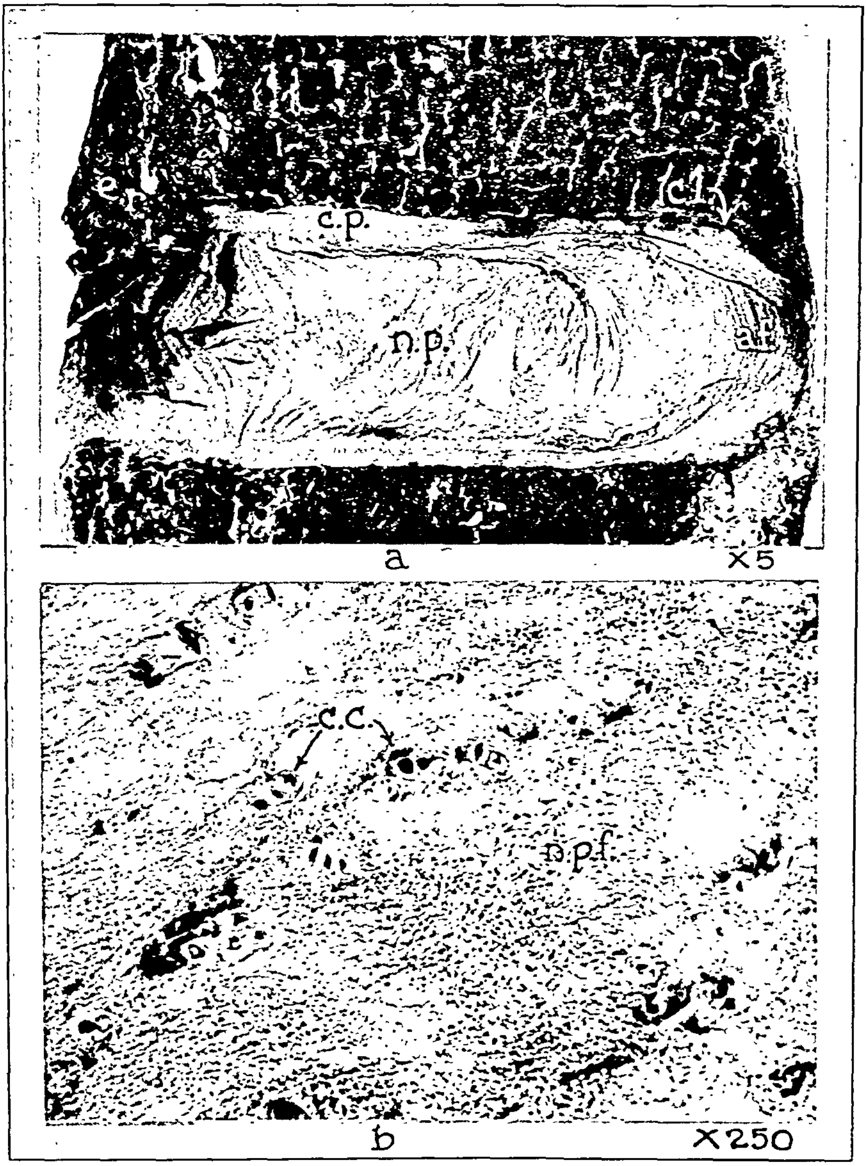

FIG. 13

A normal intervertebral disc in a twenty-four-year-old woman (first lumbar). (Two-thirds size of original illustration.)

a.f. annulus fibrosus; *n.p.* nucleus pulposus; *c.p.* cartilage plate; *c.l.* cortical layer of bone covering the adjacent surfaces of the vertebral bodies; *e.r.* epiphyseal ring; *c.c.* cartilage cells; *n.p.f.* nucleus pulposus fibers.

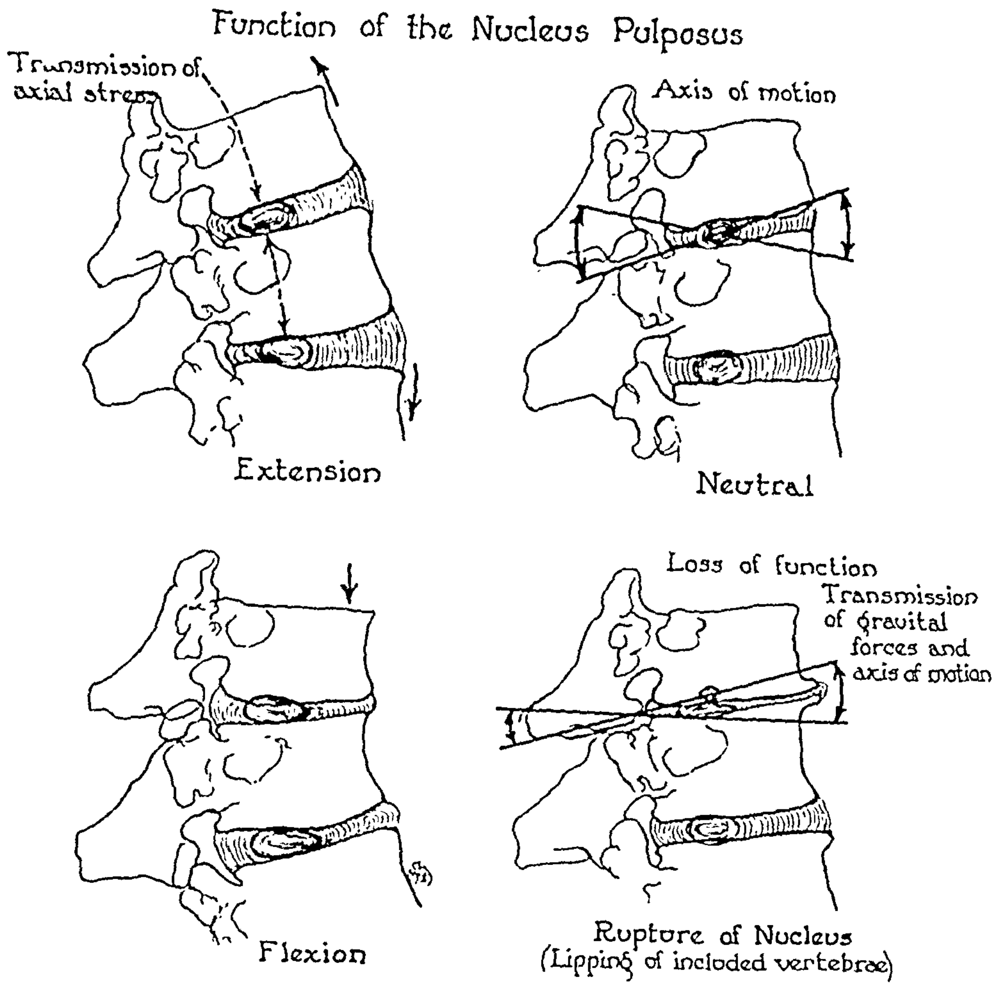

FIG. 14

A diagrammatic sketch illustrating the function of the intervertebral disc.

PATHOLOGY OF THE INTERVERTEBRAL DISC

The pathological physiology of the intervertebral disc can be best understood if one keeps constantly in mind the fact that the nucleus pulposus is the medium of transmitting pressure from one vertebra to the next. On the surface of each disc a pressure force is exerted on the concave side and a depression force on the convex side. These forces counterbalance each other, but the force of gravity persists on the nucleus which represents the transmission of the weight from one vertebra to the next by the intermediary of the nuclear axis. Any pathological process which weakens the structures confining the nucleus pulposus, invades the nucleus itself, or merely allows portions of the nuclear material to escape, will greatly interfere with the normal function of the spine.

Symptoms, characterized by pain in the back and disability, may not be expected in the spine with minute ruptures of the cartilage plate and small extrusions of the nuclear material. Schmorl[4] concluded from his studies that the nuclear prolapses which he found in thirty-eight per cent. of the spines which he studied at autopsy were of little clinical significance, but he reviewed the histories of only five of the patients upon whom

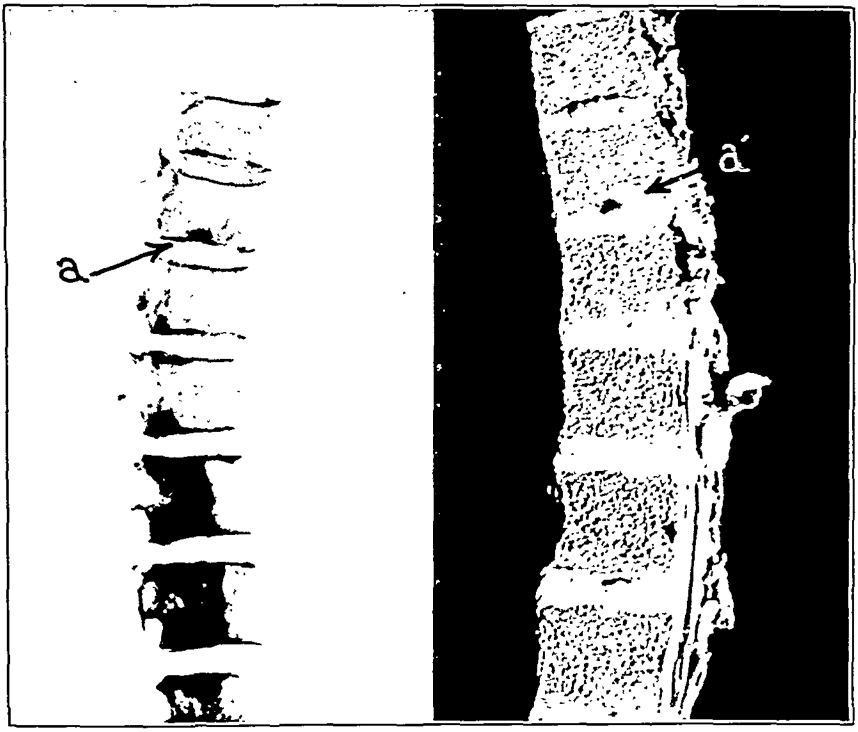

FIG. 15

Several ruptures of the nuclei pulposi are noted in the gross specimen, but only the large prolapse (*a'*) can be recognized in the roentgenogram.

autopsies were performed in his institute. Beadle [16] suggested the course of the pathological processes in a number of clinical conditions affecting the spine, but the part played by the nucleus pulposus lesions themselves has not been satisfactorily defined.

Jung and Brunschwig [18] have recently studied the innervation of the articulations of the vertebral bodies and have demonstrated sensory nerves in the anterior longitudinal ligament, but no nerve fibers of any kind were found in the intervertebral disc. For this reason trauma or disease affecting the intervertebral disc can produce subjective symptoms only in proportion to the degree in which the adjacent structures are involved.

The commonest lesion of the spine, according to Schmorl, and confirmed by our observations, is the prolapse of the nucleus pulposus into the spongiosa of the vertebral body. The mere presence of these cartilaginous nodules may not cause pain in the back. The nuclear material is extruded through a crack or other defect in the cartilage plate into the spongy bone by the force which is transmitted to that disc by the weight of the body and by the tone of the spinal muscles and ligaments. As a result of this invasion, a reaction is set up in the bone. The semifluid material is transformed into a cartilage nodule and the bone about it becomes sclerosed, forming a secondary line of defense to wall off the invad-

ing material (Fig. 15). This sclerosed bone about the nodule may be noted in the roentgenogram, but, until sufficient time has elapsed following the prolapse of the nuclear material of the disc for the reaction in the bone to take place, the roentgenological diagnosis usually cannot be made.

If only a small portion of the nucleus pulposus is extruded, the function of the intervertebral disc may not be seriously affected, and no immediate disability would be expected. The extrusion, however, of even minute portions of the semigelatinous nucleus pulposus may open avenues for dehydration of the disc and hence diminished function at an earlier age than such changes normally occur. This has been shown by the studies of Püschel and has been confirmed by us. We believe that such small *ruptures may thus be a predisposing etiological factor in the development* of arthritis of the spine years later.

If a considerable portion of the semifluid material escapes either into the spongy bone or through the fibers of the annulus fibrosus, the weight of the body and the trauma of every-day life can no longer be transmitted from one vertebral body to the next through this semifluid cushion, but must be borne in part by the fibrocartilaginous annulus fibrosus. The intervertebral disc then becomes thinner and in some instances completely wears out. When the nucleus pulposus has been destroyed, the axis of motion is shifted posteriorly to the articular facets and the weight

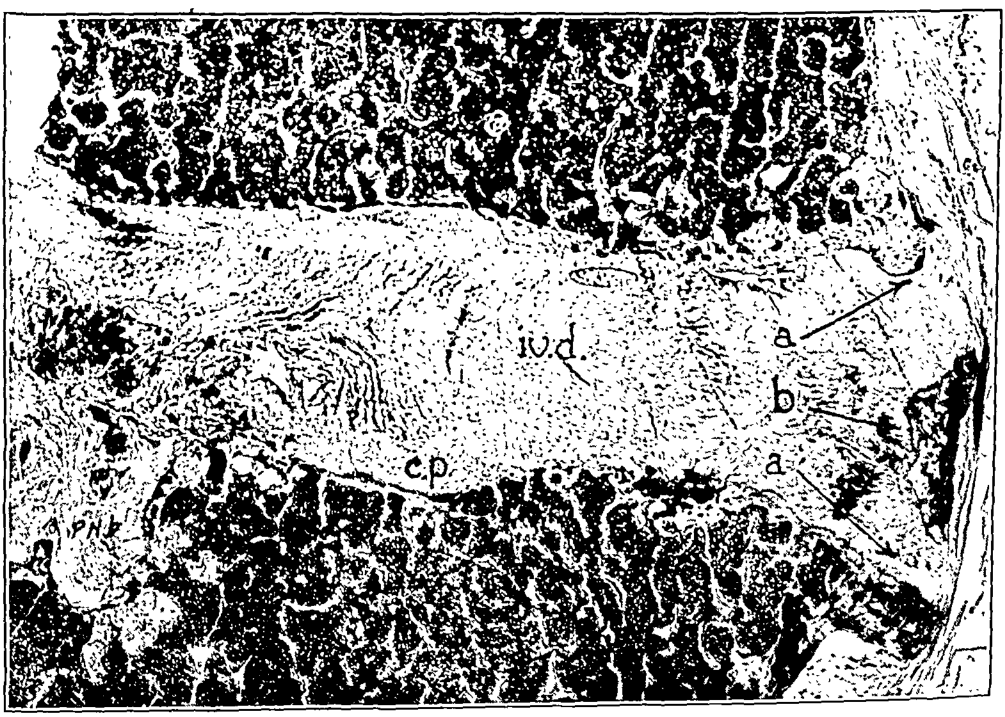

Fig. 16

This section was taken from the spine of a patient, aged forty-six years. There is a prolapse of nucleus pulposus material (*p.n.p.*) with subsequent narrowing of the intervertebral disc (*iv.d.*). Osteo-arthritis, with lipping (*a*) at the anterior edges of the vertebral bodies and beginning ossification of the anterior longitudinal ligament, has followed the diminished function of the nucleus pulposus. (Two-thirds size.)

of the body, especially in all forward or lateral bending, is transferred to the lateral or anterior portion of the vertebral bodies themselves. As a result of this the adjacent vertebrae may become sclerosed and the lipping and spurs characteristic of osteo-arthritis of the spine will be noted (Fig. 16). If the vertebral body has been softened by disease, such as tuberculosis or neoplasm, it may be eroded and ultimately completely destroyed.

Fifty-nine years before Schmorl engaged the interest of pathologists in the nucleus prolapses noted upon section of the spine at autopsy, Virchow,[8] in 1857, described a tumor found upon the inner surface of the base of the skull, and, believing it to be a growth of cartilage, named it "ecchondrosis physalifora." Müller[19], tried to show that this tumor was derived from notochordal tissue, and Steiner[20], in 1894, after a careful study of a similar case, concluded that Müller was correct in this hypothesis. Their interest did not lead to further studies of the nucleus pulposus.

Calvé and Galland[21], in 1922, and Bársony and Polgár[22], in 1925, described calcification of the nucleus pulposus. Schmorl, in 1927, reported that thirty-eight per cent. of the spines which he routinely sectioned at autopsy showed prolapses of disc material into the spongiosa of adjacent vertebral bodies. He attributed little clinical significance to these findings, but Schanz[23] suggested the possibility of a direct causal relationship between these prolapses or cartilage nodes and backache. Mau[17] and Müller[24], in 1928, and Dittrich[25], in 1929, found evidence of nuclear prolapses characterized by sclerosis about punched-out areas in the vertebral bodies, as seen in the lateral roentgenograms of cases in which there was a history of pain in the back and disability.

Andrae[26] and Schmorl[4] described prolapses of the nucleus pulposus posteriorly with extension of the disc into the spinal canal and Calvé and Galland[21] reported two clinical cases in which a diagnosis of this condition was made. Many additional articles reporting single cases of lesions of the intervertebral disc, or autopsy findings, have appeared in the journals of the last three years, mostly in the German literature, while Geist[27] and Sashin[28], as well as Calvé and Galland, have reviewed the work of Schmorl in American journals and have postulated regarding the clinical significance of the changes in the intervertebral nucleus pulposus.

In a very complete recapitulation of the entire subject of the intervertebral discs, Beadle[16] has discussed their normal and morbid anatomy in relation to certain spinal deformity.

Geist[27], Calvé and Galland[21], Sashin[28], and Beadle[16] have enumerated a number of pathological conditions in which the intervertebral nucleus pulposus is either primarily or secondarily involved. We have elected to classify the various lesions according to the primary location of the pathological process. It is obvious that there must be some overlapping in the three groups, but the following grouping has been suggested: (1) pathological conditions of the nucleus pulposus; (2) pathological conditions of the cartilage plate, and (3) pathological conditions in the vertebral bodies.

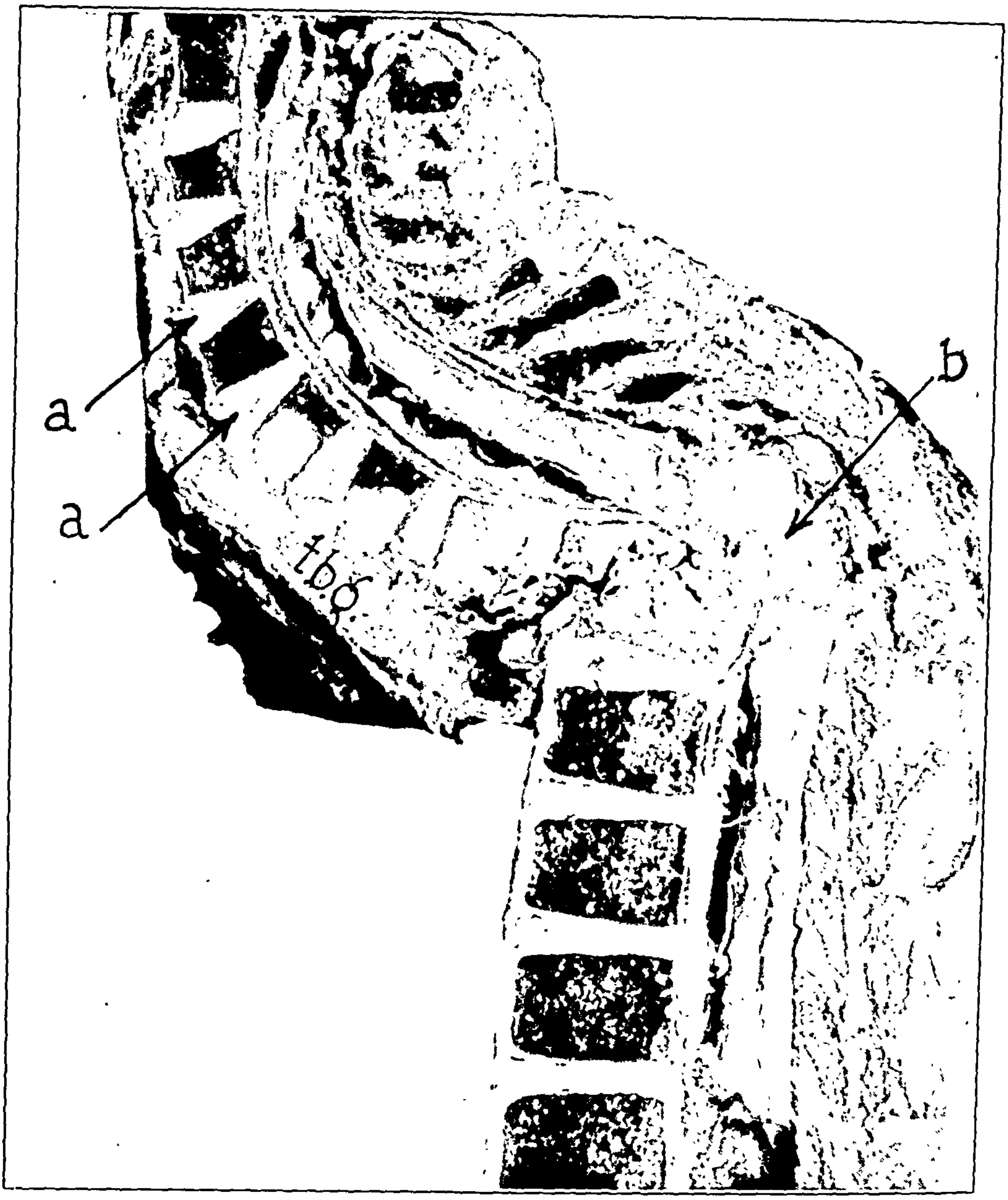

FIG. 17

The pathology of tuberculosis of the spine is demonstrated in this gross specimen. Several vertebral bodies have been destroyed and the spinal cord has been crushed at the apex of the kyphos (*b*). The hyperextension of the spine above and below the marked kyphos has resulted in a forward shift of the nucleus pulposus (*a*). Tuberculous granulation tissue (*tb.g.*) is extending upward along the vertebral bodies under the anterior longitudinal ligaments.

PATHOLOGICAL CONDITIONS OF THE NUCLEUS PULPOSUS

1. *Retropulsion or Antepulsion of the Nucleus Pulposus.* Calvé and Galland described kyphosis with nuclear retropulsion in which there was paraplegia from pressure of the bulging intervertebral disc against the spinal cord. Two similar cases were reported by Dandy [29] in 1929 and still another by Bucy [30] in 1930, but the possible rôle of the nucleus pulposus was not suggested by either author. A forward shift of the nucleus

has been noted in an attempt to compensate for the kyphos in tuberculosis of the spine (Fig. 17).

2. *Lateral Shift of the Nucleus Pulposus.* In scoliosis of the spine the nucleus pulposus has been found shifted to the side of the convexity of the curvature and, while Schmorl was not able to find evidence that this was in any way an etiological factor in the production of scoliosis, this shift of the non-compressible nucleus may be the explanation of much of the difficulty found in attempts to correct the lateral curvature.

3. *Calcification of the Nucleus Pulposus.* This condition has been described by a number of authors including Calvé and Galland, Bársony and Polgár [22], Breton [31], Lyon [32], and Dittrich [25], while Schmorl studied the condition anatomically and pathologically. This usually occurs in elderly patients in whom the diagnosis of Pott's disease may have been made. Microscopically the calcification is seen *particularly* in the shape of fine grains between the fine fibrous network of the nucleus, and in the shape of larger blocks friable in character. The cells of the nucleus are necrosed and the fibrous tissue is destroyed by the calcareous deposit (Fig. 27, Case 9).

4. *Dehydration of the Nucleus Pulposus.* With the advance of age, the percentage of water content of the nucleus pulposus becomes less and its efficiency is accordingly decreased. This dehydration phenomenon may be greatly accelerated by the production of small ruptures in the cartilage plate with the loss of portions of the nucleus pulposus material which may be microscopic in size. These degenerative changes decrease the efficiency of the spine and lead to the development of osteo-arthritis.

PATHOLOGICAL CONDITIONS OF THE CARTILAGE PLATE

The cartilage plate confines the nucleus pulposus above and below, and overlies a very thin layer of cortical bone. The two structures together are called upon to withstand the pressure exerted through the nucleus pulposus upon the vertebral body itself.

1. *Prolapse of the nucleus pulposus as a result of congenital defect* in the cartilage plate has been suggested by Schmorl. As has been demonstrated in the embryological studies, the notochordal substance is squeezed from the vertebral body by the rapidly growing cartilage cells. Occasionally notochordal tissue has been described in the vertebrae of adults and this, together with the occasional discovery by Schmorl of prolapses of the nucleus pulposus material into many of the vertebral bodies of a relatively young individual, and at about the site from which the notochord was extruded, has led to the theory that there may have persisted at this point a defect in the cartilage plate through which the prolapses occurred. The flaw in the theory lies in the fact that such a defect has not been demonstrated in the foetal spine. Such defects with early prolapses may be suggested as an additional etiological factor in the production of the so called *epiphysitis dorsalis juvenilis.*

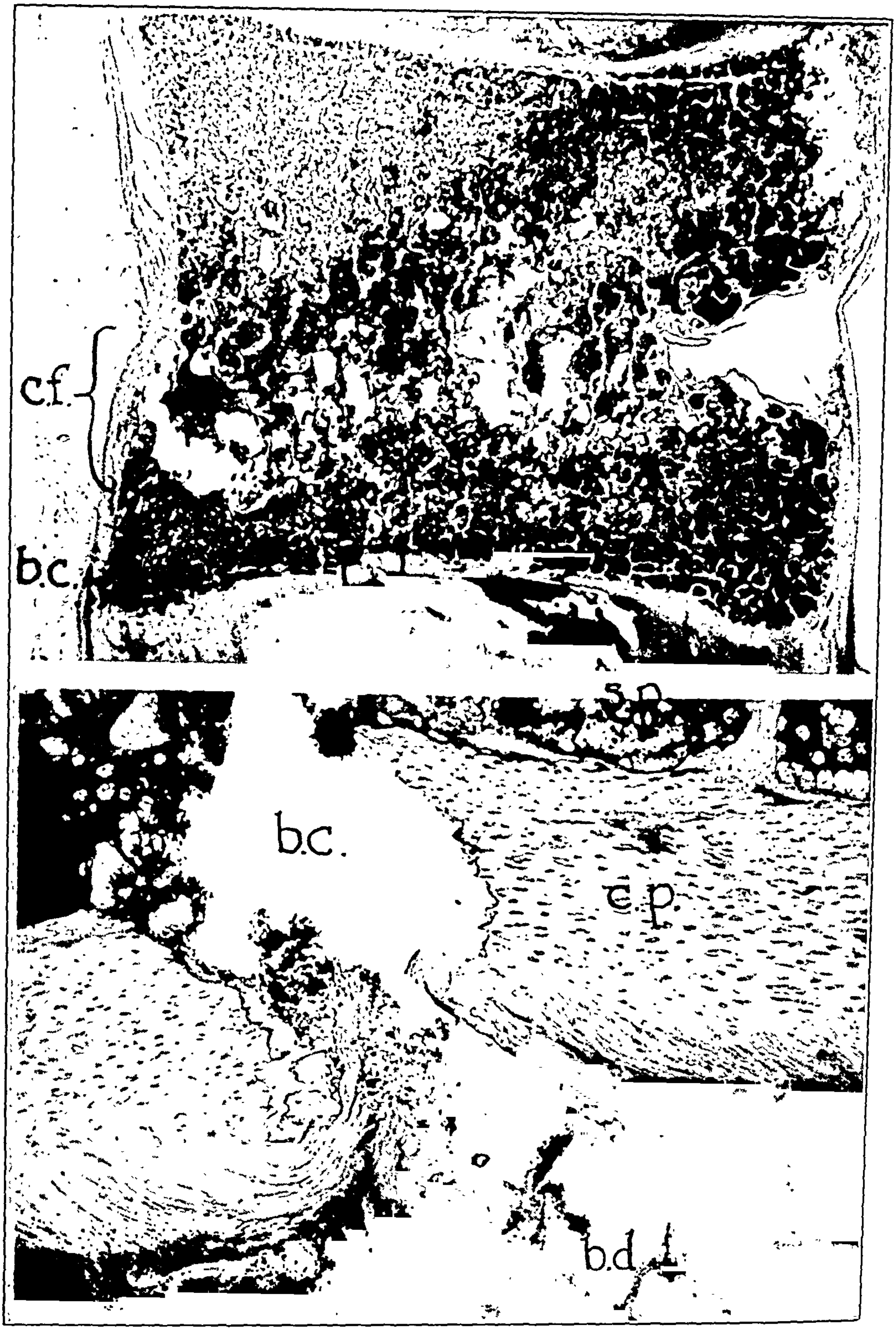

FIG. 18

The vertebral body was badly crushed (*c.f.*) when the patient jumped from a fifth story window, but only one break (*b.c.*) in continuity of the cartilage plate was found. The higher magnification shows the break (*b.c.*) in the cartilage plate (*c.p.*) and the extension of the defect into the intervertebral disc (*b.d.*) and the spongy cancellous bone (*s.p.*).

FIG. 19

The gross specimen, taken from Schmorl, illustrates the production of a cartilage mass (r) which has separated the anterior and posterior halves of the fractured vertebral body, preventing union. The x-ray shows a similar condition in a patient followed in this clinic. X-rays taken one year before, shortly after the injury, were reported "no gross pathology".

2. *Injury of the cartilage plate as a result of chronic trauma* has been suggested by Schmorl as the predisposing factor in most of the prolapses of the nucleus pulposus. These cartilage nodules were found most frequently in the spines of individuals who had been active in athletics or who had engaged in hard labor.

3. *Injury of the cartilage plate as a result of acute trauma* is often associated with *fracture of the vertebral body.* The cartilage plate is surprisingly strong and may not be opened even though a force sufficient to produce a fracture of the vertebra is exerted upon it. In a spine which we obtained from an adult male who committed suicide by jumping from a fifth story window, we found two vertebral bodies crushed, but there was only a small crack in the cartilage plate of the intervertebral disc between them (Fig. 18). In other instances, however, roentgenograms have not revealed any lesion of the vertebrae following an injury, but months or years later, when symptoms of backache have persisted, roentgenological studies have shown separation of anterior and posterior halves of a vertebral body or marked collapse of the vertebral body with narrowing of one or both intervertebral spaces adjacent to it. *Kümmel's kyphosis* may be due to injury of the cartilage plate upon both sides of the vertebral body with subsequent extrusion of the nucleus pulposus from each disc until the vertebra itself has been completely divided by a cartilage nodule (Fig. 19).

FIG. 20
Fibrillation of the cartilage plate (*d.c.p.*) is demonstrated in *A*. In *B* the plate has ruptured and nucleus pulposus material (*p.n.p.*) of the intervertebral disc (*i.v.d.*) is streaming through. The bone trabeculae in this section have become much enlarged. A cartilage nodule (*p.n.p.*) has been formed in *C* and a zone of sclerosed bone (*s.b.*) is noted about it. (Two-thirds size.)

The disturbance of circulation in the bone together with the wear and tear resulting from the loss of the two cushions or shock-absorbing effect of the nuclei pulposi might easily explain the subsequent necrosis of the bone.

4. *The fibrillation of the cartilage plate* has been described by Schmorl and has been repeatedly demonstrated in the spines which we have studied.

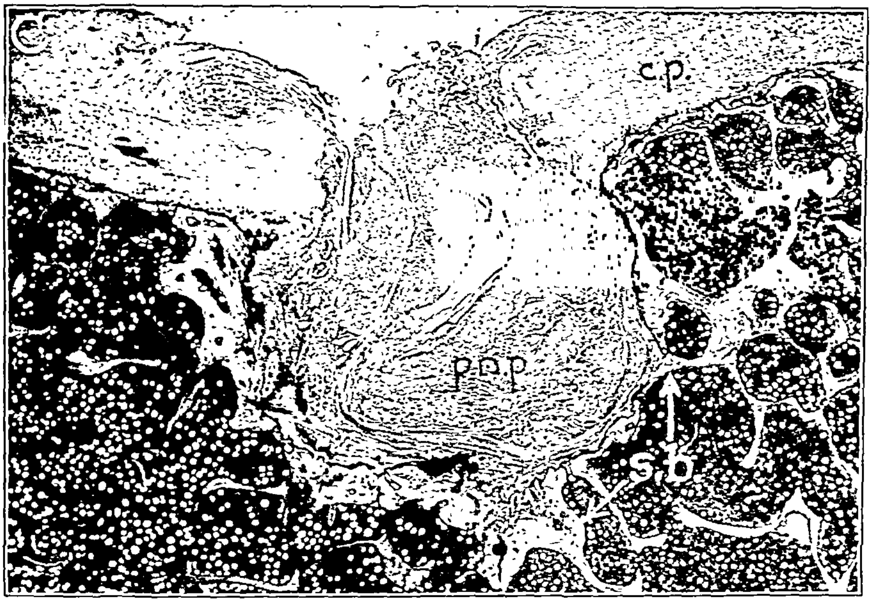

FIG. 20 (*Continued*)

It is analogous to the fibrillation in the cartilage of the knee or of the hip which is characteristic of *degenerative or osteo-arthritis* of those joints and is probably merely a result of wear and tear (Fig. 20). The loss of nucleus pulposus material through these splits in the cartilage, together with the gradual dehydration of the nucleus material, greatly lessens the resiliency and efficiency of the intervertebral disc. This leads also to narrowing of the disc, increased stress and strain upon the vertebral bodies themselves, and is followed by sclerosis, lipping, and spur formation. We are convinced from our studies that this is one of the etiological factors in the development of degenerative or osteo-arthritis of the spine.

5. *Disease processes affecting the cartilage plate.* Acute *pyogenic infections of the spine* may attack the cartilage plate and secondarily destroy the intervertebral disc itself. *Tuberculosis of the spine* is sometimes first suspected roentgenographically because of narrowing of the intervertebral space. In our pathological studies we have found sections in which tuberculous granulations were undermining and destroying the cartilage plates (Fig. 21). With the destruction of the cartilage plate, the function of the nucleus pulposus is lost and the tissue itself is extruded into the diseased vertebral body.

PATHOLOGICAL CONDITIONS IN THE VERTEBRAL BODIES

1. This includes conditions in which *the nucleus pulposus is not destroyed* but the vertebrae themselves are no longer able to stand the pressure exerted upon them. This is seen in cases of softening of the bones as in *osteomalacia, generalized osteitis fibrosa,* or *senile osteoporosis*

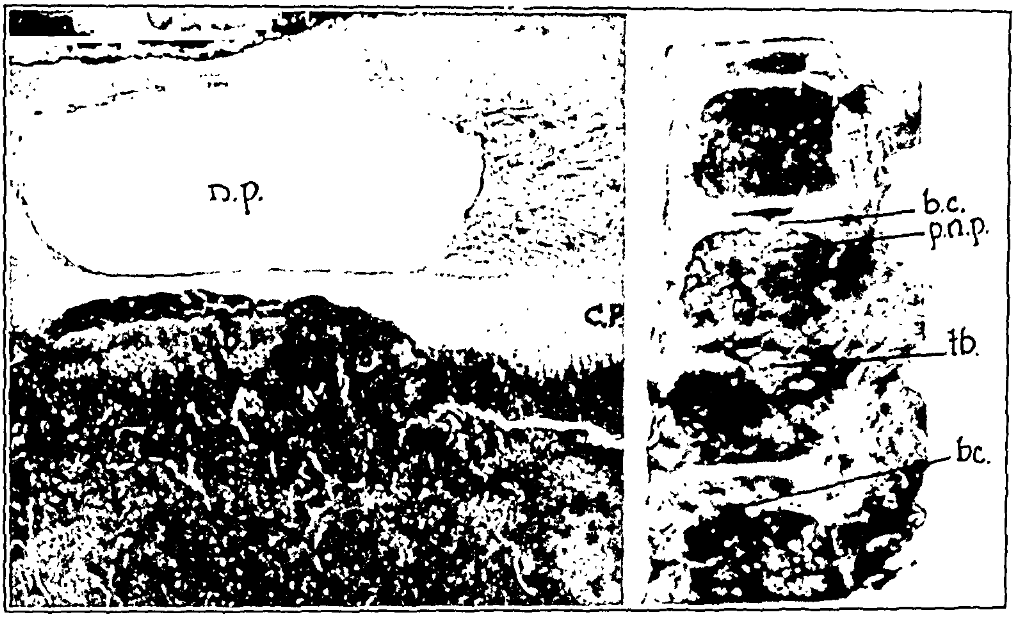

FIG. 21

Tuberculous granulation tissue (*t.b.*) has extended along the plane between the cartilage plate (*C.P.*) and the cancellous bone and the cartilage has been eroded and thinned out. In the gross specimen the tuberculous granulations have penetrated the cartilage plates (*b.c.*) and invaded the intervertebral discs. The nucleus pulposus material (*p.n.p.*) has prolapsed into the diseased vertebrae. (One-half size.)

(Fig. 22). The vertebrae may become biconcave, similar to the vertebrae of a fish, while the discs become spherical. The cartilage plates usually remain intact but they may become so thinned out as a result of the stretching that they will burst, with subsequent prolapse of the nucleus material into the adjacent vertebral body.

2. *Benign or malignant neoplasms may invade* the vertebrae and so weaken them that the nucleus pulposus will prolapse into the softened bone. The malignant neoplasms may be primary or metastatic. The lesions of this type which we have studied include: *endothelioma, multiple myeloma, sarcoma,* and *carcinoma.*

For more than two years we have sought roentgenological explanations in all cases in which there has been complaint of pain in the back and disability, or of spinal deformities. We have, whenever permitted to do so, sectioned the spine at autopsy and have studied the gross lesions microscopically.

No attempt will be made in this brief discussion to include a complete report of clinical cases. The following are merely a few which have been diagnosed as nucleus pulposus disturbances, and are included to illustrate the methods of diagnosis and our plan of treatment.

CASE REPORTS

CASE 1. *Kyphosis.* Wm. T., male, aged forty-two. Complained of severe back pain dating from an injury five years previously when he fell from a truck. This pain had become more marked until he was completely disabled. Examination revealed a rounded

kyphos of the dorsal spine. X-rays showed narrowing of the intervertebral space with sclerosis and lipping of the anterior portion of the vertebral bodies and many punched-out, sclerosed areas (Fig. 23). No foci of infection were found. Heat and massage and salicylates afforded no relief but he was immediately relieved by a properly fitted back brace. As this man had to earn his living by physical labor he objected to the inconvenience of the brace, but could not work at all without it. Using a very long, full-thickness graft from the tibia, the spine was fused, February 24, 1932. He has been completely relieved by this internal splint and has been working again for several weeks.

CASE 2. *Epiphysitis Dorsalis Juvenilis.* H. P., female, aged eighteen years. Patient came complaining of severe dorsal backache and moderate dorsum rotundum of two years' duration. There was no definite history of injury, although she had fallen from riding horses a number of times. X-rays revealed numerous punched-out areas in the vertebrae with narrowing of the intervertebral space. She was relieved by wearing a back brace (Fig. 24).

CASE 3. *Prolapse of Nucleus Pulposus Following Acute Trauma.* L. D., aged seventeen years, patient of Dr. Steindler. Complained of pain and a feeling of crunching in the upper lumbar region whenever he resumed the erect position after stooping over. Four years previously, during a wrestling match, his back had been bent sharply over his

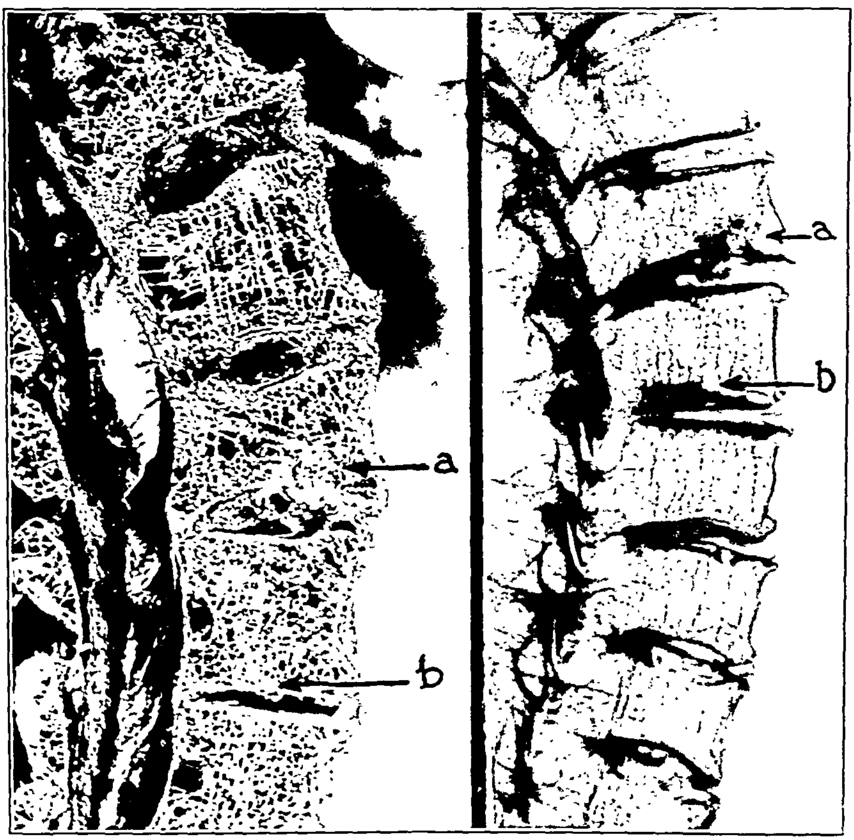

FIG. 22

This museum specimen demonstrates the biconcave, osteoporotic vertebrae with several ruptures of the nuclei pulposi, two of which (*a* and *b*) can be identified in the x-ray.

opponent's knee. Pain and weakness in the back lasted for two weeks. Similar attacks of pain recurred intermittently for the next four years and for the past four months it had been continuous. An x-ray revealed definite narrowing of the intervertebral space between the first and second lumbar vertebrae and a sclerosed, punched-out area in the body of the second lumbar vertebra. He is wearing a back brace with complete relief of symptoms, but, if he attempts to discard the back brace, the symptoms immediately return.

CASE 4. *Nucleus Prolapses Associated with Scoliosis.* Mary P., aged sixteen years, was followed in Dr. Steindler's clinic for eleven years because of congenital club feet. The spine was found to be normal at each of several physical examinations. In the eleventh year a slight scoliosis was noted, although there were no subjective symptoms. One year later the patient began to complain of intermittent, dull aching pains, located in the lower back, gradual in onset and progressive in nature, and aggravated by exercise. X-rays showed the typical punched-out areas suggestive of nucleus pulposus prolapse in several of the lumbar vertebrae. She was completely relieved of symptoms by a back brace.

CASE 5. *Osteoporosis of the Spine.* M. Mc., aged fifty years, came to the University

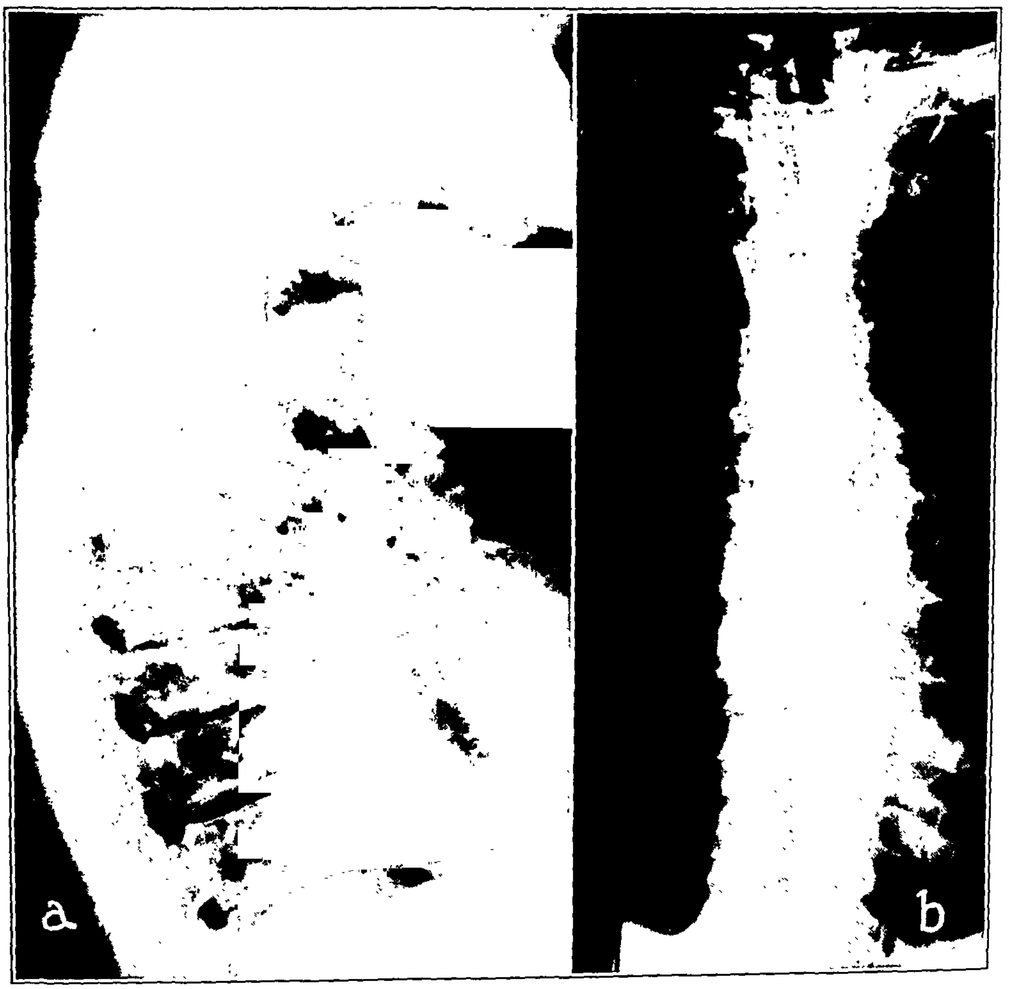

FIG. 23

Case 1. The lateral roentgenogram (*a*) shows the rounded kyphos, narrow intervertebral spaces with sclerosis and lipping of the anterior portion of the vertebral bodies and many punched-out areas, suggesting ruptures of the nuclei pulposi into the spongy cancellous bone. The anterior-posterior view (*b*) shows the bone graft which extends from the second to the twelfth dorsal vertebrae and effectively splints the spine.

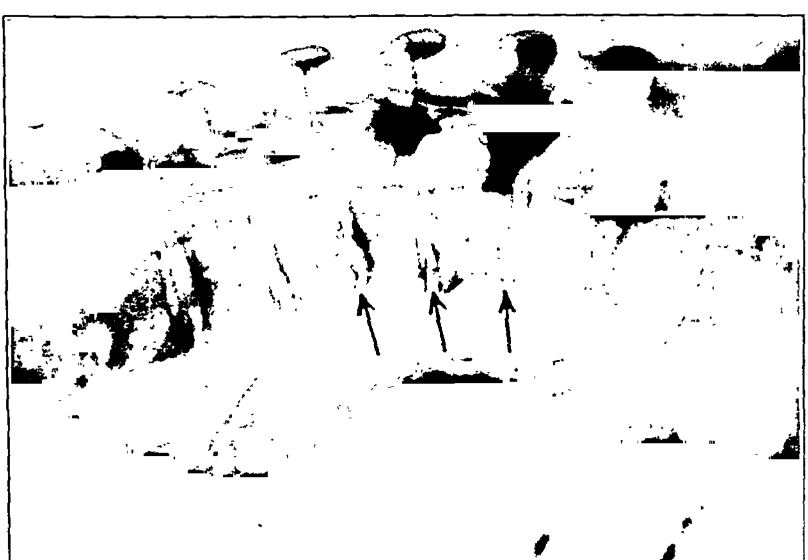

Fig. 24

Case 2. Note the irregularity of the adjacent surfaces of the vertebrae with narrowing of the intervertebral spaces.

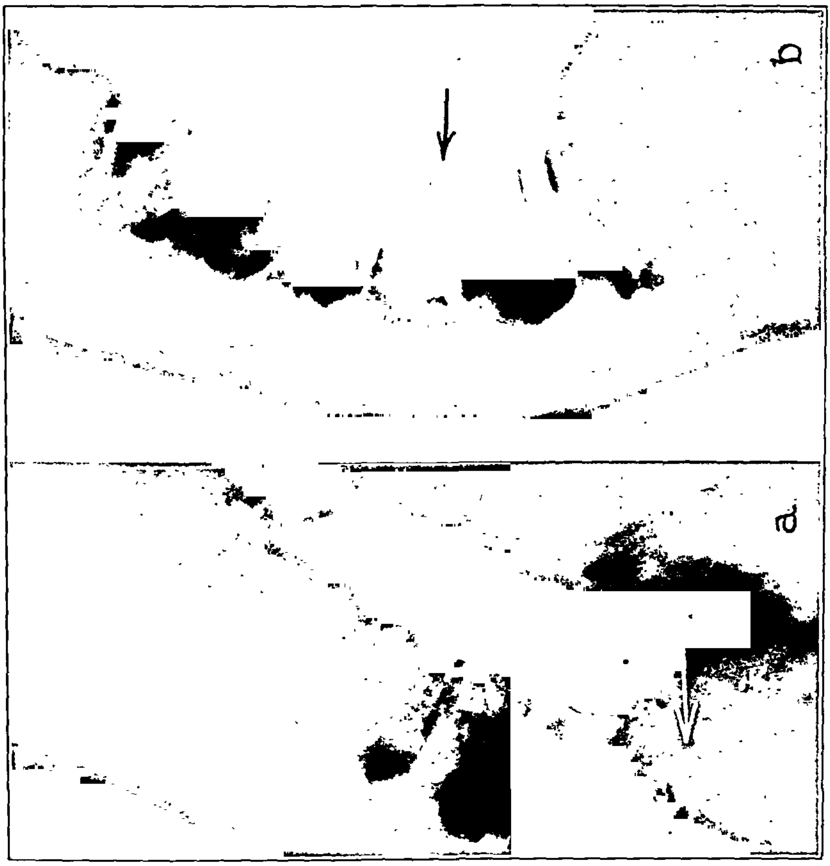

Fig. 25

Case 6. The roentgenograms show the compression fracture of the vertebral body with kyphosis of the spine, narrowing of the adjacent intervertebral spaces, and lipping of the vertebral bodies anteriorly.

FIG. 26

Case 7. The extensive destruction of vertebral bodies by tuberculosis is illustrated both in the roentgenogram and the photomicrograph. The cartilage plate (*C.P.*) has been broken through and the nucleus pulposus (*N.P.*) has prolapsed (*P.N.P.*) into the diseased vertebral body (*V.b.*). (Two-thirds size.)

FIG. 26

of Chicago Clinics because of pain and weakness in the dorsal and lumbar spine. The back was rounded and patient had decreased about two inches in height during the year. X-rays showed biconcave, fish-shaped osteoporotic vertebrae, with many ruptures of nuclei pulposi. She has been partially relieved by a back brace.

CASE 6. *Compression Fracture of the Spine.* A. C., aged forty-eight years, came to us complaining of difficulty in walking, associated with severe pain in the back and both legs, following a fall of thirty feet three years before. Examination revealed a marked dorsolumbar kyphos, marked limitation of the spine in all of its movements, and partial paralysis in both lower extremities. The roentgenograms revealed compression fractures of the tenth dorsal and the first lumbar vertebrae and punched-out areas in several other vertebrae. The spine was hyperextended and then fused September 18, 1930, from the eighth dorsal to the fourth lumbar vertebrae by means of two full-thickness, tibial bone grafts. The pain has been completely relieved and the patient has been able to work for the past eight months (Fig. 25).

CASE 7. *Tuberculosis of the Spine.* C. C., aged thirteen years. This patient had complained of pain in the back for six years and she had been treated for tuberculosis of the lumbar spine by means of casts and rest in bed until coming to our clinic. X-rays showed tuberculosis of the second, third, and fourth lumbar vertebrae with loss of the intervening intervertebral discs. The patient died of tuberculous meningitis one month after fusion of the spine, and the diseased portion of the spine was removed at autopsy. This revealed destruction of the intervertebral discs with extension of the nucleus pulposus material into the vertebral bodies (Fig. 26).

FIG. 27

Case 9. The calcified nucleus pulposus is clearly visualized in both the lateral and the anterior-posterior views.

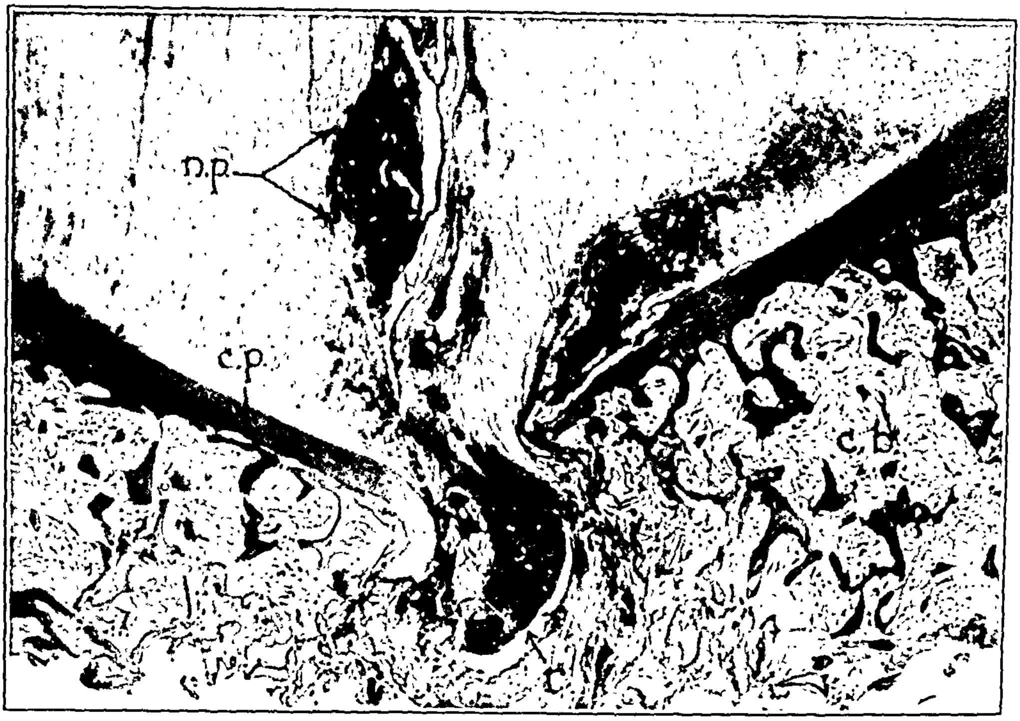

Fig. 28

Case 10. The softened vertebral body has been depressed until the cartilage plate (*c.p.*) has become thinned out and finally ruptured. The nucleus pulposus material (*n.p.*), still containing many pigmented-cell nuclei, is streaming through the defect and forming a node (*r*) in the cancellous bone. (Two-thirds size.)

Case 8. *Charcot's Disease.* A. A., male, aged forty-three years. Complained of pain in the lower back for one week only. X-rays showed erosion or crushing of the third, fourth, and fifth lumbar vertebrae with marked narrowing of the intervertebral discs. These vertebrae showed marked evidence of bone proliferation with sclerosis and marginal lipping. He was markedly relieved by back brace.

Case 9. *Calcification of the Nucleus Pulposus.* E. L., female, aged forty years. (Bone and Joint Service of University of Michigan.) Complained of pain in the lower dorsal region of the spine penetrating through to the abdomen, worse in the morning and during activity. Examination revealed a full range of motion in the spine without any muscle spasm. X-rays revealed a calcified mass in the intervertebral disc between the tenth and eleventh dorsal vertebrae. This was confined to the portion of the disc just posterior to the middle third, which is typically occupied by the nucleus pulposus. She has been somewhat relieved by wearing a corset (Fig. 27).

Case 10. *Carcinoma Metastases to the Spine.* B. O'N., aged thirty-one years. Patient was first seen January 24, 1930, when a diagnosis of inoperable carcinoma of the uterus was made. The diagnosis was proved by biopsy. She was treated vigorously with x-ray and radium. In April, 1930, she first complained of backache. This pain persisted until her death from the carcinoma in April, 1931. The portion of the spine in which she had complained of back pain was removed at autopsy. A relatively recent rupture of the cartilage plate with extrusion of a large amount of the nucleus pulposus material was found upon section of the spine (Fig. 28).

Case 11. *Multiple Prolapses of the Nucleus Pulposus.* V. C., aged twenty-five years. She complained of pain in her dorsal and lumbar spine and of sleeplessness of four years' duration. She attributed her condition to a difficult labor four years before admission. A kyphos was present in the lower thoracic and lumbar region of the spine. Lateral x-rays showed the punched-out areas in the mid-dorsal and the lumbar spine which are characteristic of prolapses of the nuclei pulposi. She was relieved by a back brace.

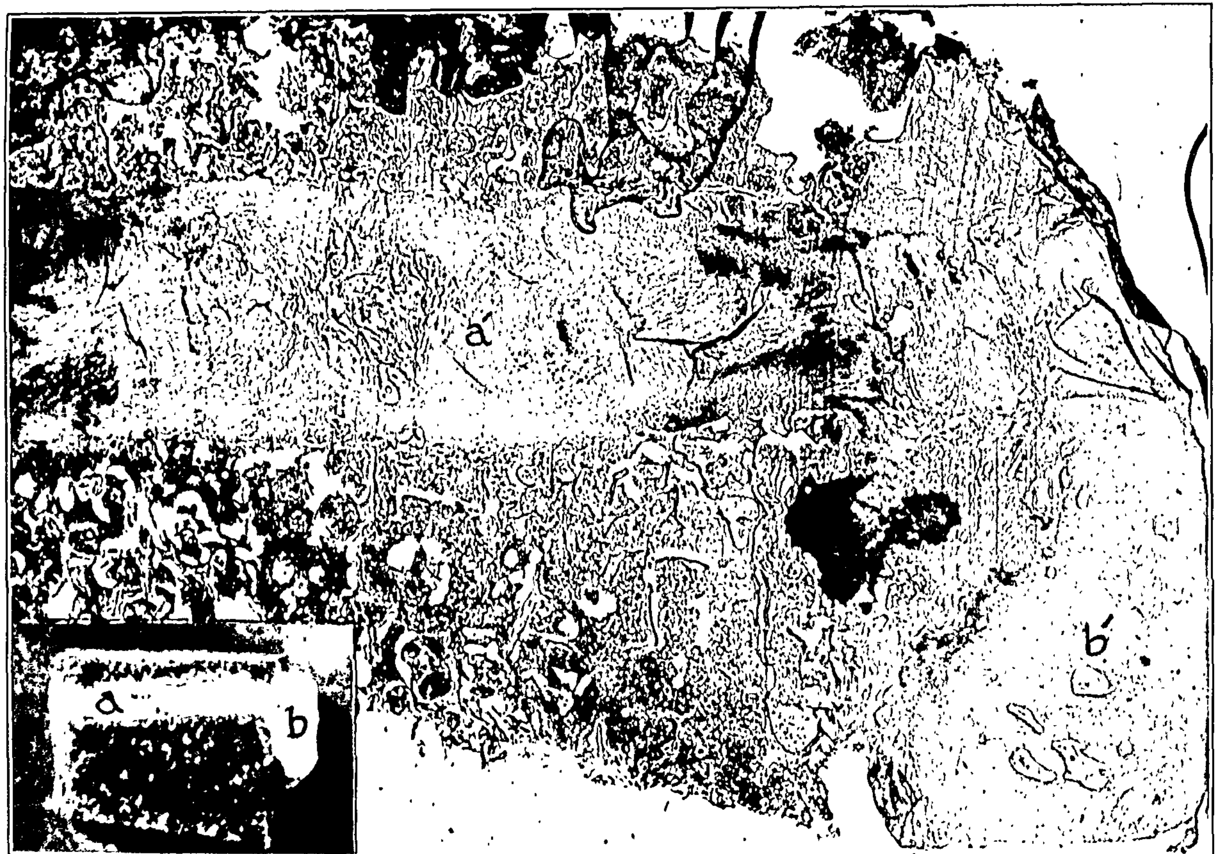

Fig. 29

Fig. 29

This specimen was obtained from the spine of a patient who died of generalized carcinomatosis. The finding in the spine was incidental and apparently had produced no clinical symptoms. In the gross specimen the nucleus pulposus has forced its way back through the annulus fibrosus, and into the spinal canal, elevating the periosteum and depressing the dura, forming a cartilage body (*b*), a part of which is illustrated in the photomicrograph (*b'*). The intervertebral disc (*a* and *a'*) is narrow and the cartilage plates show early degenerative changes characterized by fibrillation.

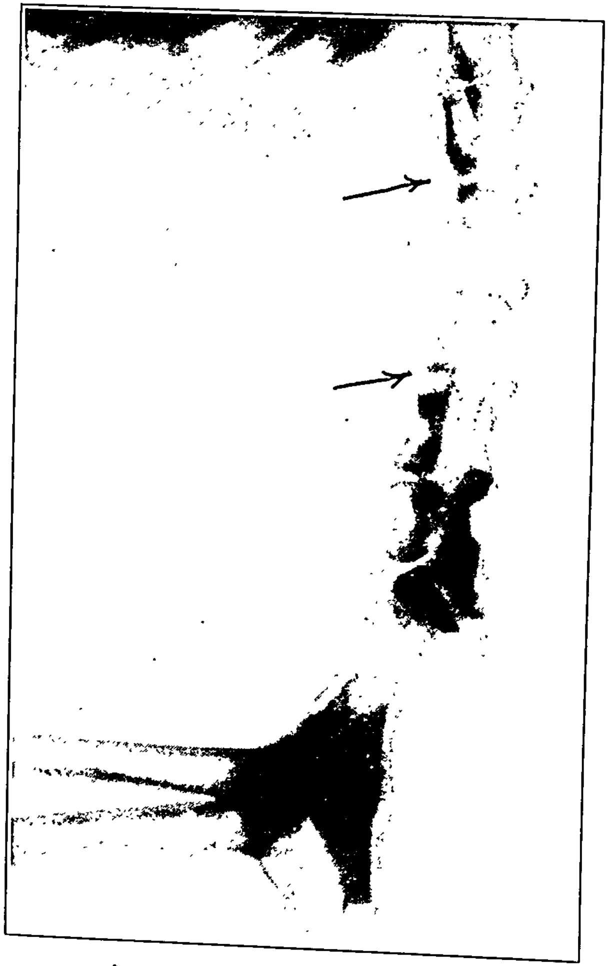

FIG. 30

Dog 815. Three months after operation. The loss of intervertebral space, sclerosis of adjacent portions of the vertebral bodies, and osteophyte formation are indicated by the arrows.

FIG. 31

Dog 821. Three months after operation. This spine, which has been sectioned longitudinally, demonstrates grossly and in the roentgenograms the sclerosis of vertebrae and osteophyte formation which followed removal of the nucleus pulposus material.

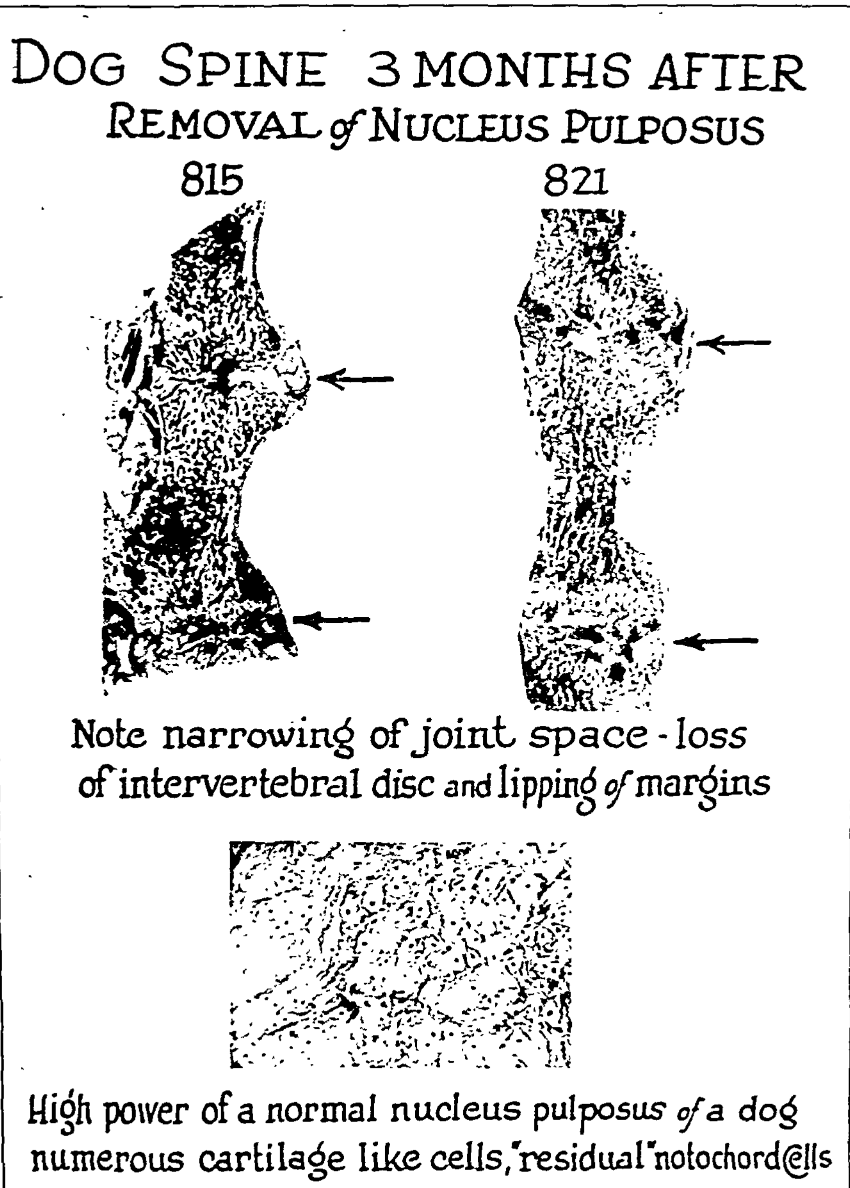

FIG. 32

Dogs 815 and 821. These reduced photomicrographs illustrate the similarity between the changes noted in these dog spines and those recognized clinically as osteoarthritis of the spine.

EXPERIMENTAL STUDIES OF THE NUCLEUS PULPOSUS

The first experimental studies of the nucleus pulposus were those of Ribbert[33] when, in 1895, he proved that the Virchow tumor known as ecchondrosis physalifora could be produced experimentally in the rabbit by puncturing the intervertebral ligament and permitting a portion of the

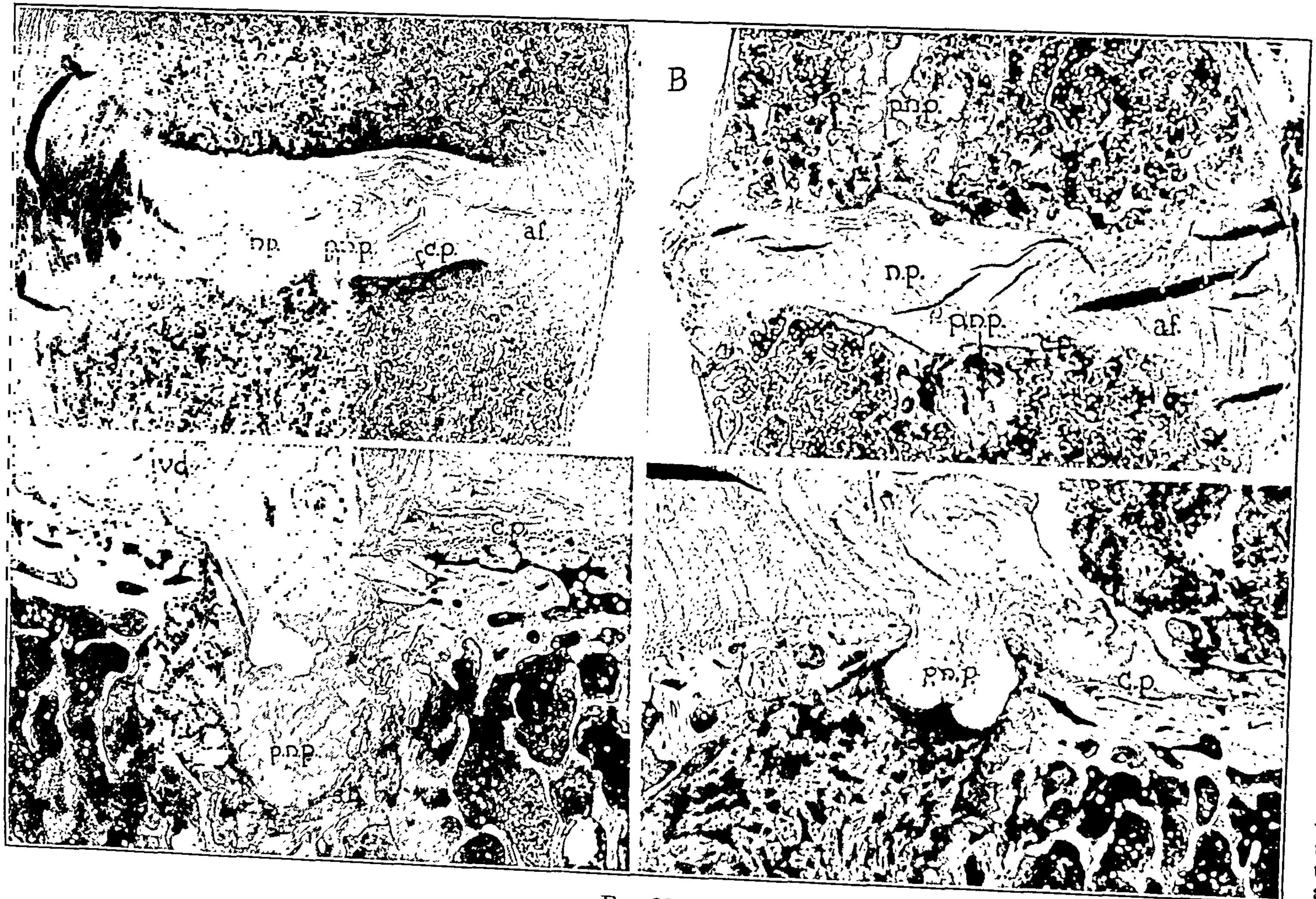

Fig. 33

Fig. 33

Photomicrographs of sections of spines of dogs in which the intervertebral disc was injured from two to five months before the animals were sacrificed. (One-half size.)

In *A* and *B* the anterior fibers (*a.f.*) of the annulus fibrosus were incised with a scalpel, permitting some of the nucleus pulposus (*n.p.*) material to escape. At the same time a curette was inserted and the cartilage plate (*c.p.*) was damaged, resulting in a small prolapse of the nucleus pulposus (*p.n.p.*), narrowing of the intervertebral discs, and sclerosis of the subchondral cortical bone.

In *C* a small drill was passed through the vertebral body, the cortical bone, and the cartilage plate of the inter-

FIG. 33 (*Continued*)

vertebral disc (*iv.d.*). Nucleus pulposus material has been extruded through the defect into the cancellous bone, forming a typical Schmorl cartilage nodule (*p.n.p.*). A similar prolapse is noted in *D* following fracture of the vertebral body with a heavy chisel, with a resultant break in the cartilage plate.

nucleus pulposus to escape. This nuclear material lying in the connective tissue and muscle near the ligament was found to grow for some time and to form a characteristic ecchondrosis physalifora, which he called a chordoma (Fig. 29).

Roux [34] has studied the effect of pressure on the intervertebral disc and the vertebrae themselves.

Püschel [15] estimated the water content of a series of normal and degenerated intervertebral discs in the various age-periods. Her results and our own have been described elsewhere in this paper.

In the hope that we might be able to reproduce experimentally some of the pathological conditions which clinically have been thought to be due to injuries or disease of the nucleus pulposus, we have undertaken a series of experiments. We chose as our subjects monkeys and adult dogs. The lumbar spine was exposed by intra-abdominal incisions and the dorsal spine by rib resection posteriorly and reflection of the parietal pleura from the sides of the vertebral bodies. The intervertebral discs were injured in various ways, and at several levels in the spine. A small drill was passed through the bodies of the vertebrae at an angle until the drill perforated the cartilage plate at the site of the nucleus pulposus. At another level a vertebral body was fractured by passing a wide chisel through it transversely and a third vertebra was fractured longitudinally so that the fissure extended to the cartilage plate. In a second series the annulus fibrosus was incised with a sharp scalpel. Upon withdrawing the scalpel a semifluid, gelatinous, slightly turbid material was immediately exuded in an amount of from five-tenths to one cubic centimeter, obviously under considerable pressure.

In our series of thirty-two dogs and two monkeys, only sixteen of the dogs survived the operation long enough to obtain results of value. In two dogs, in which the vertebral bodies were exposed by a paravertebral incision in the lumbar region and the intervertebral disc was opened with a small knife and the nuclear material was curetted out, there was a mild infection which persisted for from two to three weeks. In subsequent x-ray examinations (Fig. 30) the intervertebral discs were found to have completely disappeared and the adjacent bone surfaces became markedly sclerosed with spur formation and lipping of the anterior edges. These dogs developed a definite kyphosis (Fig. 31). They were sacrificed three months after operation and the spines were sectioned and studied microscopically. The discs at the site of injury had disappeared, the bone was dense, and there was marked hyperostosis and new bone formation very similar to that observed clinically in cases of marked osteo-arthritis of the spine (Fig. 32).

In the series of animals in which small drill holes were made through the cartilage plates, nuclear prolapses typical of the cartilage nodules described by Schmorl were found. All of these animals were sacrificed before sufficient time had elapsed to permit any marked bone sclerosis about the extruded nucleus pulposus material (Fig. 33).

Similar cartilage nodules were found extending into the cracks in the cartilage plates created by the chisel with which the vertebral bodies were fractured. In those vertebrae where the cartilage plate was not injured by the chisel, but where merely the bone was fractured, no prolapses were found.

In every instance where nucleus pulposus material had been permitted to escape, there was definite narrowing of the intervertebral disc and, when most of the nucleus was curetted out, the adjacent vertebrae showed early changes of typical hypertrophic or osteo-arthritis of the spine and fibrosis of the material remaining in the space previously occupied by the nucleus pulposus.

CONCLUSIONS

1. The assumption of von Luschka and of later embryologists that the intervertebral nucleus pulposus is a vestigial remnant of the notochord has been disproved. It is a highly specialized structure.

2. The nucleus pulposus is not formed from degeneration of the annulus fibrosus fibers as postulated by Virchow and Dursy.

3. This anatomical entity is formed by the proliferation and mucoid degeneration of the notochord cells, followed by a fibrocartilaginous invasion derived from the original mesenchymal intervertebral cells, which form a fibrocartilage envelope.

4. The cartilage plate and the epiphyseal ring are genetically one structure and are comparable to the epiphyses of the long bones.

5. The nuclei pulposi are essential for the normal physiological functions of the spine.

6. Loss of nucleus pulposus material as a result of trauma or disease is probably one of the frequent etiological factors associated with pain in the back and disability.

7. Clinical and experimental evidence has been presented to indicate that degenerative, hypertrophic arthritis of the spine may result from the loss of the intervertebral shock absorber and hydrodynamic ball bearing of the spine, the nucleus pulposus.

8. If the cartilage plate of the intervertebral disc of a dog is injured by a scalpel or drill, nuclear material prolapses into spongiosa and a cartilage nodule forms.

9. If the nuclear material is allowed to escape, the rest of the disc becomes thinned out and the margins of the adjacent vertebrae become sclerosed with subsequent marginal lipping.

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OSTEOGENESIS IMPERFECTA

With a Suggestion for Treatment *

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There is a condition of the bony skeleton in the human, which has been given various names, and which has been studied from the histopathological, pathological, biochemical, and clinical standpoints without disclosing any definite knowledge as to its etiology, and in which no apparently successful mode of therapy has been developed. We refer to the condition most commonly called osteogenesis imperfecta.

Hess has described two forms of the disease,—one, osteogenesis imperfecta congenita which occurs at or soon after birth; and the other, osteogenesis imperfecta tarda in which the symptoms appear in late infancy or early childhood. This latter is probably the osteopsathyrosis idiopathica which was described by Lobstein in 1834.

We wish to report the observations on two cases of this condition which were treated apparently successfully by the administration of thymus gland by mouth. This method of treatment was suggested to us by the work of Glässner and Hass in which, both in animal investigation and in clinical trial, they studied the effects of the administration of thymus on bone healing. The literature of this work can be divided into two groups: (1) the effect of thymus extirpation on the healing of fractures; (2) the influence of thymus injections or feedings on the healing of fractures. Experimental results would seem to indicate that thymus extirpation causes a smaller than normal amount of callus formation.

Using cats from the same litter, under ether anaesthesia, the left leg was fractured and in one-half of the animals the thymus was removed. One-half of the animals received no thymus, while the other half received daily injections (subcutaneously) of one cubic centimeter of thymus extract for fourteen days. Every eighth day x-ray films were taken and at the end of four weeks the animals were killed.

Results. The thymectomized animals showed less callus formation than the control animals, while the thymectomized cats who had received the thymus extract injections all showed a voluminous periosteal and medullary callus.

These experiments were repeated a number of times.

In the second series of experiments Glässner and Hass studied the effects of extracts of other endocrine glands on the healing of fractures. Using older cats of approximately the same weight they fractured the left leg and for twenty days thereafter gave daily injections of one cubic centimeter of different extracts, including egg albumin, testicular substance, and parathyroidin. The results of this work proved to their

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satisfaction that, of all the extracts, the thymus exerted the best callus-stimulating effect. Next in line, although far behind, was parathyroid extract.

Following this work Glässner and Hass decided to try thymus extract in humans and they make the observation that man tolerates relatively large doses of thymus without harm. Two patients of the same age were selected upon whom they performed linear osteotomies for bow legs. One received thymus injections and the other was used as a control. A comparison of the films showed no difference between the two cases after four weeks, but three months later there was a marked change. The thymus-free patient had motion in the operative region and very little callus, while the patient who received the thymus-extract injections had completely consolidated periosteal and medullary callus.

CASE REPORTS

CASE 1.* D. McH., male, aged eight at the time of the first observation. This boy was seen at his home March 26, 1929, by the reporter, following a fall.

Physical examination revealed evidences of a fracture at the upper end of the right humerus and a fracture of the upper end of the right thigh. An x-ray taken immediately after his admission to St. Mary's Hospital disclosed a fracture of the surgical neck of the right humerus in good position and an intertrochanteric fracture of the right femur with slight decrease in the normal angle between the neck and the shaft. The fractured humerus was treated by rest and bandaging to the side. The fractured femur was fixed by a Whitman cast which was allowed to remain on for eight weeks. The boy returned to school the following September and sometime after that, a decided limp being noticed, he was questioned and complained of pain in the right ankle. X-rays at this time showed a fracture of both internal and external malleoli and a fracture across the lower end of the tibia with union in good position. In February 1930 he sustained a fracture of the middle of the shaft of the left femur for which he was treated at another hospital by a plaster case. After the removal of this case he returned to school and, on standing beside his desk, he placed his full weight on the left leg and turned his body and the femur gave way. Another x-ray taken at St. Mary's Hospital showed a fracture through the middle of the shaft of the left femur at the site of an old fracture; callus was small and not well calcified.

Suspecting the probability that this was a case of osteogenesis imperfecta tarda we further investigated his history with the following information: One of his clavicles was fractured at the age of five, followed by fractures of the other clavicle and of the left humerus following trivial falls; then followed fractures of the right humerus and right femur mentioned above and the fracture of the right ankle mentioned above, then the first fracture of the left femur and the recurrence. In one year, therefore, he fractured the right humerus, right femur, right tibia, and left femur, with recurrence of the latter fracture in about a year.

Aside from being a small boy who did not walk until eighteen or twenty months of age, and who did not talk until three years of age, his previous history was essentially negative. His father and mother, one brother, and five sisters are living and well and careful investigation failed to disclose any evidence of a susceptibility to fractures or blue sclerotics on either side as far back as can be determined.

Examination. The fractures mentioned above were found on physical examination and confirmed by x-ray. Except for a slight grade of anaemia, the red blood count being 3,930,000, all blood studies were within normal limits.

In July 1930, while wearing a brace on the left leg to prevent a tendency to turn in,

* Case 1 was presented before the Philadelphia Academy of Surgery in December 1931.

he fell and fractured the left tibia at the junction of the upper and middle thirds while the brace was on the leg. This fracture healed rapidly.

It was at this time that we reviewed the work of Glässner and Hass and placed this boy on thymus gland—two grains twice daily—and in the time that has elapsed since then no further fractures have occurred although this boy has led a normal active life, has been able to play ball, ride a bicycle, roller-skate, and has had numerous falls. Later on we suggested this treatment to Dr. A. Bruce Gill, who had seen this boy with us in consultation, and he very kindly gave us the report of Case 2.

Case 2. C. S., female. Admitted to the University Hospital January 31, 1930. Marked outward bowing of right femur and bowing of right humerus present.

Past Medical History. When nine months old she suffered a fracture of the right femur when turning in her crib. Was taken to the Jefferson Hospital where she remained eight months. Several months after her return home she had another fracture of the same bone and was taken to the Methodist Hospital where she remained nine months. At the end of another seven months she suffered a third fracture of the right femur. She spent nine months in the Children's Seashore Home at Atlantic City. All these fractures healed readily. Had had whooping-cough, chicken-pox, measles, and pneumonia.

Family History. Is the only child living. The first child was born deformed and lived but two months. Father and mother are living and well.

Operation. April 3, 1930. Manual osteoclasis of right femur to correct the deformity. Following the operation the fracture healed well and she was discharged from the hospital on June 19, 1930.

Readmitted to the University Hospital September 15, 1930, with a fracture of the lower third of the left tibia caused by a fall while walking.

On October 6, 1930, she had a fracture of the right tibia while lying in her crib, and on November 26, 1930, the right femur again was broken.

On November 30, 1930, she was put on thymus-gland medication, fifteen grains daily. No other fracture occurred until June 6, 1931, when there was a fracture of the upper third of the right tibia.

The administration of the thymus gland was continued until November. It was then stopped because her appetite seemed to be affected. Two months afterward she again had a fracture of the left femur (January 9, 1932).

During the period of administration of the thymus the child improved in general health. She lost her fear of being handled and began to walk. Her weight increased. X-ray examinations showed marked increase in density of the shafts of the long bones.

On her first admission to the hospital she had a hemoglobin of seventy-four per cent., and the blood count showed 3,500,000 red blood corpuscles and the white blood cells varied between 12,000 and 17,000. Blood calcium was ten and two-tenths milligrams per 100 cubic centimeters and blood phosphorus five milligrams. Her head was large and square. The anterior fontanelle was still open at five years of age. She was poorly developed and undernourished. The upper extremities were short and there was marked bowing of both humeri. She had a rachitic rosary. She had a slight exophthalmos and the sclerae were a bluish white. There were no neurological signs nor symptoms.

For a time she was treated with viosterol and calcium, but these were discontinued when the administration of thymus gland was begun.

Conclusions. Before thymus gland was given this patient was having a new fracture every few months. After this medication was begun, she did not have a fracture for seven months. The last fracture occurred seven months later and two months after the administration of thymus gland was discontinued.

CONCLUSIONS

Although the treatment suggested here may be empirical we believe that further trial should be given the administration of thymus gland in this condition because two definite patients have ceased having fractures

while thymus was being administered, and one of them at this writing has failed to have any fractures for approximately two years since the treatment was begun.

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CONGENITAL DISLOCATION OF THE HIP: THE TREATMENT AND RESULTS IN CASES UNSUITABLE FOR BLOODLESS OR OPEN REDUCTION

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The treatment of congenital dislocation of the hip in older children and in young adults has received considerable attention. This is also true of those early cases that show a shallow acetabulum and have more or less instability of the hip joint. Numerous operative procedures have been devised and subjected to clinical trial and investigation. We feel at this time that the shelf operation gives the best hope of providing a hip that is stable, painless, and functionally satisfactory. It is for this reason that we are reporting this series of cases.

During the past five years the shelf operation has been performed in twenty-three instances at the Children's Orthopaedic Hospital and in the private practice of Dr. C. F. Eikenbary, Dr. John F. LeCocq, and Dr. Edward LeCocq. Sixteen patients have been treated. The results have been, on the whole, very satisfactory. In the cases having a shallow acetabulum, with or without a partial luxation of the femoral head, the procedure has consisted of wedging the top of the acetabulum downward, then filling in and building a shelf above the head. In the frank dislocations, the method has been, in each instance, a turning down of a shelf from the side of the ilium over the head, the angle between the ilium and the shelf being filled in with bone chips taken from the iliac crest. In performing the operation the capsule is not entered, the shelf being formed entirely extracapsularly, just above the femoral head.

The results are here briefly summarized:

CASE 1. D. S. Age thirteen years. Bilateral dislocations.

July 2, 1928: Attempted reduction of right hip by open operation unsuccessful; so, at the same sitting, a shelf was formed.

September 10, 1928: Shelf operation, left.

April 17, 1929: Right hip practically ankylosed. Good shelf on left.

June 6, 1930: Subtrochanteric osteotomy of right femur, for correction of adduction and flexion deformity.

July 30, 1930: Little motion in right hip. Sixty degrees of motion on left side, good adduction, abduction, and rotation. Some limp on left side.

CASE 2. W. L. Age five. Right hip.

August 20, 1928: Manipulation and plaster. Successful reduction. Acetabulum very shallow.

January 4, 1932: Slight instability of hip because of shallow socket. Shelving done

April 7, 1932: Good shelf. Hip stable. Practically no limp. Very good result. (See Figure 1.)

CASE 3. S. K. Age thirteen. Bilateral.

August 31, 1929: Shelf, right.

November 18, 1929: Shelf, left.

January 20, 1930: Plaster removed.

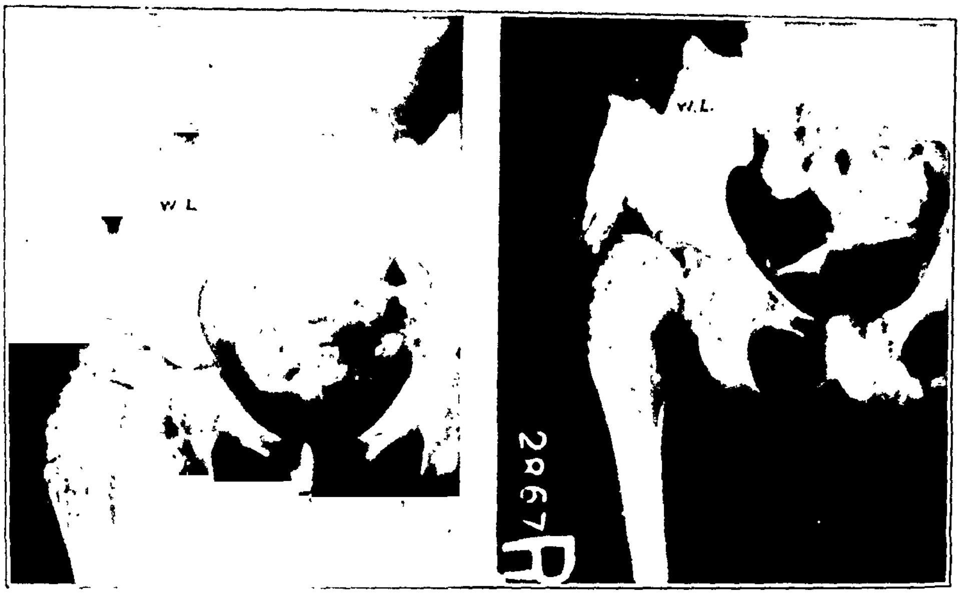

FIG. 1
Case 2. Before and after operation.

June 19, 1930: Hips stable.

September 29, 1930: Osteotomy of femur for correction of knock-knee deformity.

November 29, 1930: Good shelves and sockets. Walks well with only slight limp. Excellent result.

CASE 4. M. G. Age eleven. Left hip.

June 17, 1931: Shelf operation. Plaster for four months.

January 29, 1932: Walks with only a slight limp. Stable. Good range of motion. Excellent result.

(See Figure 2.)

CASE 5. Y. K. Age nine. Bilateral.

July 2, 1928: Open reduction, right.

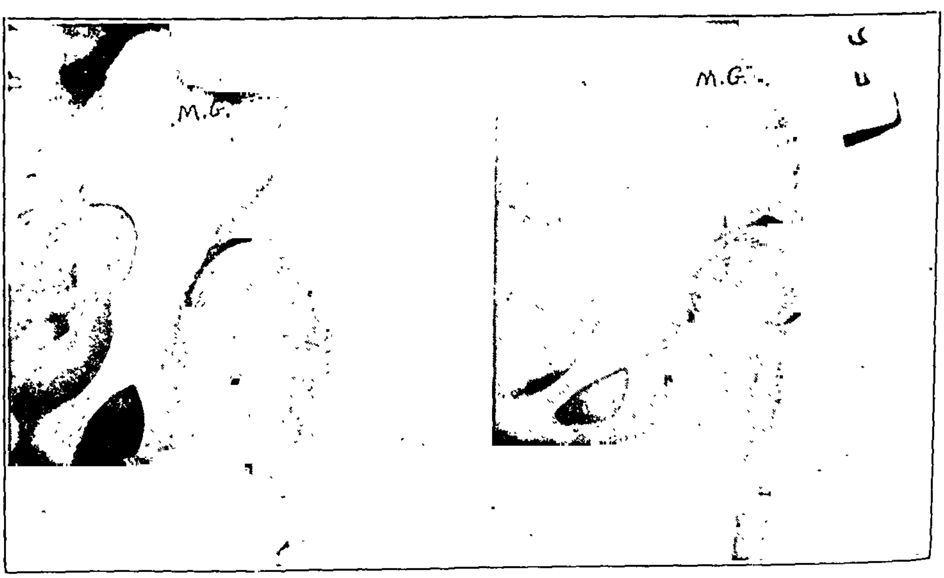

FIG. 2
Case 4. Before and after operation.

Fig. 3
Case 6. Before and after operation.

August 4, 1928: Reluxated. Reoperated, head reduced into acetabulum.
March 4, 1929: Shelf operation, left hip. Right hip very stiff. Manipulated.
November 25, 1929: Arthroplasty, right.
June 18, 1931: Right hip ankylosed. Left hip stable: has good motion. Walks fairly well.

Case 6. D. M. Age ten. Left.
May 11, 1931: Shelf operation.
March 18, 1932: Walks without a limp, and without fatigue. Excellent result. (See Figure 3.)

Case 7. E. B. Age three. Bilateral.
June 11, 1930: Manipulation.
November 12, 1930: Right hip in place. Left dislocated.

Fig. 4
Case 7. Before and after operation.

FIG. 5-A
Case 10. Before operation.

FIG. 5-B
Case 10. After operation.

November 17, 1930: Shelf operation, left.

January 21, 1931: Excellent position and shelf present. Some instability of right hip.

March 22, 1931: Shelf, right.

June 24, 1931: Good function in both hips. Excellent result.

(See Figure 4.)

CASE 8. L. M. Age seven. Right.

September 1, 1928: Open reduction. Shallow acetabulum.

December 27, 1928: Plaster removed. Hip reluxated.

February 25, 1929: Shelf operation.

October 8, 1929: Fair motion. Hip stable. One inch of shortening.

August 20, 1931: Walks very well. Motion limited. Fair result.

CASE 9. Z. W. Age thirteen. Bilateral.

April 15, 1929: Shelf, right.

May 6, 1929: Shelf, left.

October 20, 1929: Walking without support.

November 5, 1930: Walks remarkably well. Most excellent result.

CASE 10. R. Y. Age nineteen. Bilateral.

April 24, 1928: Shelf operation, left.

May 18, 1928: Shelf, right.

February 12, 1929: Walking well.

May 18, 1931: Walks very well, with a slight waddle. Does not tire and has no pain. Excellent result.

(See Figures 5-A and 5-B.)

CASE 11. L. E. Age six. Right.

July 8, 1931: Shallow acetabulum. Hip unstable. Shelf operation performed.

September 1, 1931: Good shelf. Normal motion. Excellent result.

CASE 12. G. B. Age twenty years. Bilateral.

January 9, 1932: Shelf operation, left.

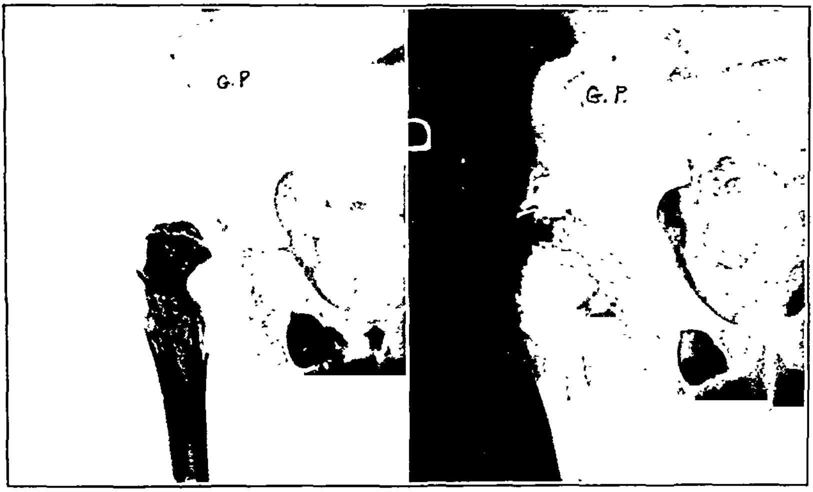

FIG. 6
Case 13. Before and after operation.

March 10, 1932: X-ray shows good shelf. Walking with aid of crutches and complains of no pain. Will obtain good result.

CASE 13. G. P. Age nine. Right.
January 25, 1932: Shelf operation.
March 25, 1932: Excellent shelf present.
April 14, 1932: Walks with very little limp. No pain. Very good result.
(See Figure 6.)

CASE 14. V. T. Age four. Bilateral. Shallow sockets present on both sides.
October 28, 1929: Open reduction, right.
January 27, 1930: Open reduction, left.
March 20, 1930: X-ray shows that both hips have redislocated.
August 17, 1931: Shelf, right.
September 14, 1931: Shelf, left.
November 28, 1931: Good shelves present. Walking.
January 12, 1932: Walking very well. Shelves holding satisfactorily.
Following this the patient developed Pott's disease and she is now recumbent on a Bradford frame.

CASE 15. R. S. Age five. Right.
August 15, 1930: Shelf operation.
December 19, 1930: Good shelf. Still has limp.
February 12, 1932: Good stability and motion. One-half inch of shortening. Walks with a slight limp. No pain.

CASE 16. P. G. Age three. Right.
January 23, 1932: Very shallow acetabulum present.
January 25, 1932: Shelf operation.
April 16, 1932: Plaster removed. X-ray shows excellent shelf. Good mobility, no shortening.
May 14, 1932: Normal range of motion. Slight limp still present. Will probably obtain a perfectly normal hip.

CONCLUSIONS

The *shelf operation has been performed in twenty-three instances*, for the relief of symptoms due to old, unreduced congenital dislocations of the hip, and for the purpose of providing stability in those hips having shallow sockets, with or without a partial dislocation of the femoral head.

Favorable results have been obtained in nineteen of the operations. Stability has been secured, the limp has been lessened or corrected, and pain has been relieved.

Two of the cases gave only fair results, a marked degree of shortening being present.

Two of the operations resulted in ankylosis of the affected hips. It is to be noted that in each of these cases the shelf operation had been preceded by an attempted open reduction.

We feel that in the older cases, where open reduction is not likely to be successful, the shelf operation is preferable to open operation and reduction. The latter procedure often results in ankylosis of the affected hip, whereas the shelf operation, in nearly every instance, gives a freely movable hip which is painless and has good function.

RADIAL EXOSTOSIS COMPLICATING ANTERIOR DISLOCATION OF THE ELBOW

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Anterior dislocation of the elbow is an extremely uncommon condition. In 1922 Cohn [1] collected twenty-two cases from the literature and added one of his own. In seven of Cohn's cases the forward dislocation was associated with a fracture of the olecranon or coronoid process. In 1923 Tees [2] collected twenty-eight cases of which eight were accompanied by fracture of the olecranon. Last year Simon [3] collected thirty-one cases of anterior dislocation of both bones of the forearm and added one of his own. In the case of anterior dislocation of the elbow reported by Tees and McKim [4] the humerus had herniated through the lower end of the triceps.

In posterior dislocations of the elbow Cotton [5] points out that the stripped-up periosteum "is the source of the massive formation of new bone behind and to the outer side of the joint, regularly found at operation on old luxations". This complication is particularly evident in anterior dislocations. In the words of Cohn [1], "In all cases which have been verified by operation or autopsy there has been an extensive laceration of the ligaments about the joint and a stripping-up of the muscles in the immediate vicinity from the respective bones".

The stripping-up of the attachment of the brachialis anticus from the lower end of the humerus, with the resulting hemorrhage and possibly with the displacement of osteogenetic cells, predisposes toward ossification in this region (See Blencke [6]). Osteomata of the brachialis anticus following posterior dislocation have been reported by Costantini [7]; and, following a dislocation of the elbow of undetermined variety, by Lucchese [8]. In their textbook Baetjer and Waters [11] show a reduced dislocation of the elbow, followed by a "deposition of bone in the torn ligaments, producing ankylosis".

It would seem that the conditions for the formation of an ossification complicating dislocations of the elbow would be more favorable in the anterior variety of dislocation than in the posterior, because of the stripping-up of the brachialis anticus. In the following case the osteoma or exostosis involved the brachialis anticus, but seemed to originate from the head of the radius. It followed a severe compound anterior dislocation of the elbow, accompanied by fracture of the ulna. The details of the treatment of the fracture of the ulna have previously been reported as part of a paper on the operative treatment of fractures. In brief:

The patient, W. K., aged thirty-four, sustained a compound anterior dislocation of the left elbow, accompanied by a fracture of the ulna with loss of substance, on July 3,

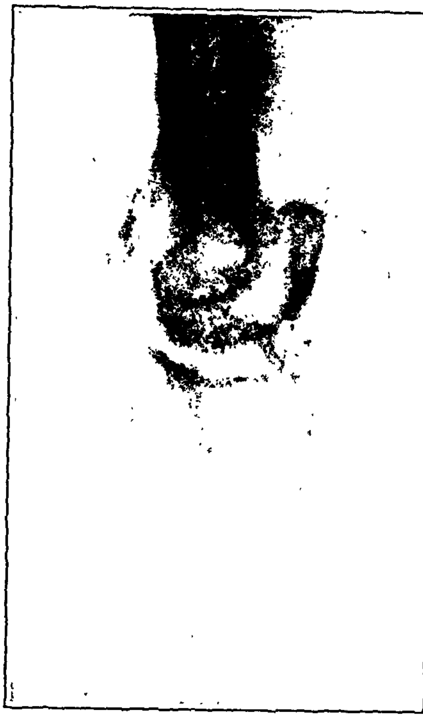

FIG. 1

Exostosis of the head of the radius following anterior dislocation of the elbow with severe compound fracture of the ulna.

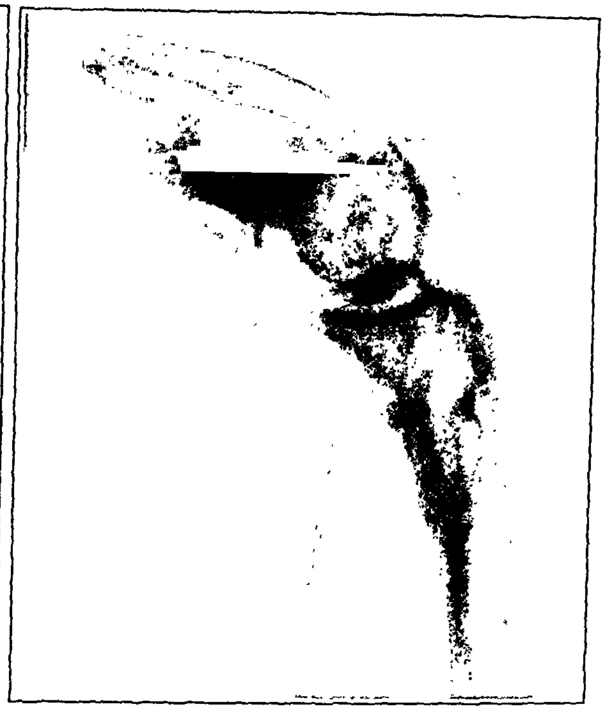

FIG. 2

Exostosis shown in Fig. 1, but with the arm flexed, showing the exostosis apparently impinging upon the humerus.

1931. The split shaft of the ulna was approximated by a Parham band and the olecranon process was wired to the shaft of the ulna across the gap occasioned by the loss of bone substance. The extensive wound was treated by the Carrel-Dakin method and eventually healed. The wires and band were removed.

Nine months after the injury, x-ray examination (Fig. 1) showed a curved exostosis *originating from the head of the radius. This bony protuberance completely eliminated supination and pronation and, moreover, as is evident from the x-rays, seemed to explain the limitation of flexion.* The arm could be flexed to no less than a right angle, in which position the distal end of the exostosis seemed to impinge upon the humerus (Fig. 2).

On March 10, 1932, a longitudinal cubital incision was made under ethylene anaesthesia. A bloodless field was secured by the use of a tourniquet. Using the biceps tendon as a guide, the head of the radius was located. The exostosis was carefully dissected free and removed. The head of the radius was then removed by means of a Gigli saw. Supination and pronation of the forearm now became possible, but flexion was unimproved. *A separate mesial incision was then made and part of the coronoid process of the ulna was chiseled off.* Flexion was still obstructed and it was thought to be due to the unusual conformation of the joint or to shortening of the triceps.

On April 30, 1932, seven weeks after the operation, seventy-five per cent. of supination and pronation was present, but flexion was still limited to about ninety degrees (Figs. 3 and 4). The patient is undergoing active physiotherapy and it is expected that considerable further improvement will occur. The patient has found the arm much more useful since the ankylosis preventing supination and pronation has been removed.

SUMMARY

1. Anterior dislocation of the elbow is rare and may be accompanied by fracture of the ulna.

FIG. 3

Appearance of the elbow shown in Figs. 1 and 2 after excision of the head of the radius.

FIG. 4

Lateral view of elbow shown in Fig. 3, showing excision of the head of the radius and removal of a part of the coronoid process of the ulna.

2. Anterior or posterior ossification in the soft parts may be a complication of anterior or posterior dislocation of the elbow.

3. Such ossification may cause serious interference with supination and pronation or with flexion of the elbow, and often should be removed surgically.

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TENDINITIS OSSIFICANS TRAUMATICA

BY HERBERT L. BRUMBAUGH, M.D., CINCINNATI, OHIO

From the Department of Orthopaedic Surgery, University of Cincinnati *

The metaplasia of tissues has always held considerable interest. The production of bone at anatomical positions not usually found to be bony has always aroused more than a transient interest. The "bony shoulders" of the German soldiers and the "bony thighs" of certain horsemen have been the subject of a great amount of comment both in professional and lay literature.

The condition of tendinitis ossificans closely resembles myositis ossificans. It has been described as a very rare condition usually traumatic in origin [1]. The diagnosis has usually been made by roentgen examination; often, however, by operation. Two methods for the production of this condition have been advanced,—first, displacement of fragments of periosteum into a soil fertile for osteogenesis; second, an actual metaplasia of tendon fibers into cancellous bone [2]. Both of these would undoubtedly require trauma. The histological studies of Weidenreich [3] tend to show that "the osteoblasts are the usual fibrous cells without any specific endowment. They may be developed in every connective tissue under certain conditions, among which the increased afflux of lime salts seems to be of the greatest importance." Leriche's theory of ossification [3] requires two conditions,—first, an embryonic tissue formation; second, an afflux of lime salts. Trauma, causing minute hemorrhages, can easily give rise to granulation tissue, which in reality is a form of embryonic tissue. It is hard to show in many cases how trauma would cause the second condition to be fulfilled. Bone atrophy which would result in an afflux of lime salts to the traumatized tissue can rarely be demonstrated by the roentgen film.

The mesodermal origin of both bone and tendon has been established. The thesis has been advanced that bone will undergo the same changes as soft tissue which has a common origin, modified by the mechanical stresses and static alignments under which it is found. The reverse might be proposed,—namely, that soft tissue can undergo the same changes as bone under similar conditions.

Esau [4] reported a case which developed acutely on an apparently infectious basis and required surgical treatment. In 1851, an autopsy report in The Transactions of the Pathological Society of London [5] gave an instance of ossification in the psoas, iliacus, semimembranosus, and semitendinosus tendons in a man of seventy, who had been bedridden with chronic arthritis for twelve years. The German writers have reported a number of cases, pointing out the periosteal origin as the more likely

* Service of Dr. Albert H. Freiberg.

FIG. 1

Roentgenogram of knee before operation, showing complete ossification of the patellar tendon.

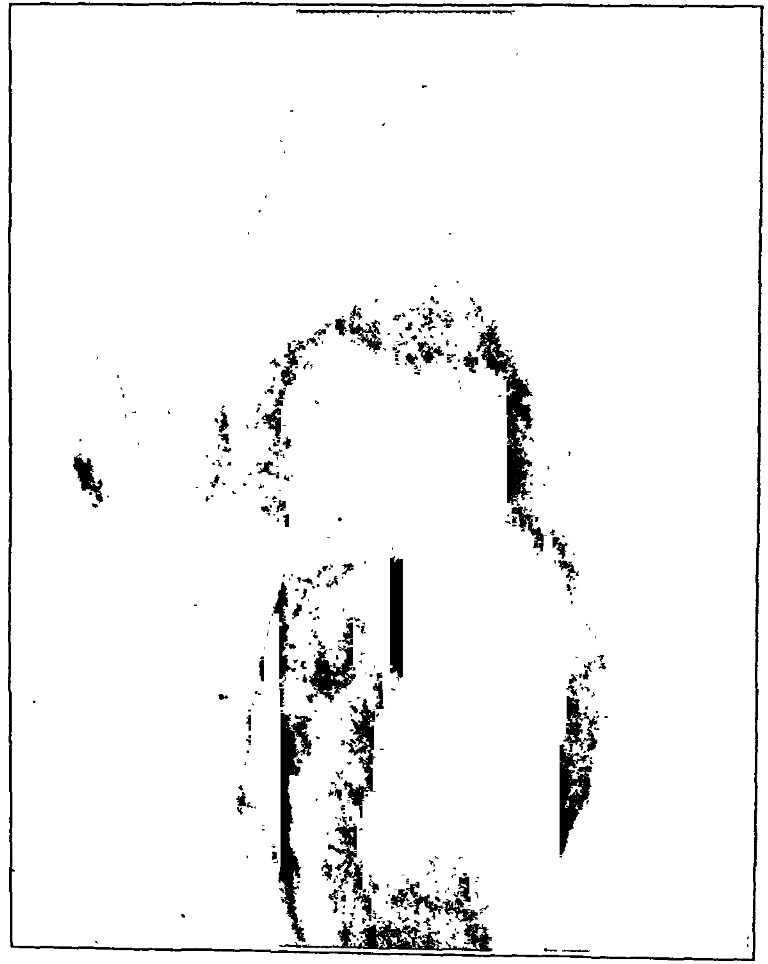

FIG. 2

Roentgenogram of knee after operation. The bony mass has been removed. Braided silk sutures were used to replace and restore the tendon.

explanation. Nearly all had a history of trauma. Seven cases have been reported showing ossification of the tendo achillis. Those reported by Horing [6], [7] and Densow [8] were undoubtedly traumatic in origin. Koehnlein [9] reported one case resulting from osteomyelitis of the calcaneum. Cases reported by Steiger [10], Jacobsthal, and Meyers could not be definitely attributed to trauma. An equal number have been reported involving the ligaments of the knee. Haglund [13], Sonntag (2 cases), Beaher, and Koehnlein (3 cases) reported cases involving these structures, all of which apparently had their origin in trauma. It is interesting that in the case reported by Beaher, the patient was a professional dancer. Frangenheim [11], Oliver [12], Koehnlein, and Fiedler reported cases of traumatic ossification in tendons of the elbow. Von Seemen and Koehnlein reported like cases but did not associate trauma with the etiology. The triceps tendon was usually involved. In only two of the reported cases was fracture noted as the result of the original injury.

CASE REPORT

H. D., aged thirty-two, male, colored. Porter by occupation, but frequently engaged in both amateur and professional tap-dancing exhibitions. Entirely well before the onset of his present illness. Admitted because of pain and limitation of motion in the right knee. Trauma had been sustained eight months previously by a fall on this knee. This was followed by intermittent dull, aching pain for four months which then became constant and moderately severe for the four months preceding his admission. This pain had been increased by weight-bearing and relieved temporarily by rest and heat. The past history revealed an infection of both gonorrhoea and syphilis. There had been no treatment for the latter.

The right knee presented the only interesting physical signs. They were: swelling anteriorly over the lower half of the patella, visible and measurable atrophy of the thigh and calf muscles, tenderness over the lower patella and patellar tendon, periarticular thickening of soft tissues, slight increase in local heat, definite spasm of the hamstring muscles, flexion to 150 degrees with full extension.

Roentgen examination showed a bony mass between the lower pole of the patella and the tibial tubercle, occupying the position of the patellar tendon. The Kahn reaction was strongly positive. The urine and blood examinations were insignificant.

At operation, a bony mass, replacing the patellar tendon with only a small membranous portion of the tendon remaining anteriorly, was found. The bony mass was completely excised. This procedure caused a rent in the remaining portion of the tendon approximately one and a half centimeters long. Braided silk sutures were woven back and forth in an attempt to restore the continuity and to strengthen the part remaining. The wound was closed without drainage. The extremity was immobilized in a long leg plaster cast with the knee in full extension. On histological examination this mass was found to be normal cancellous bone. The convalescence was com-

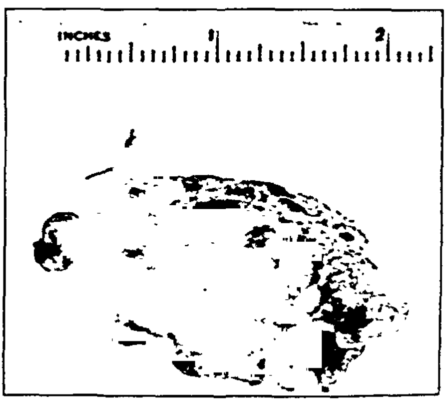

Fig. 3

Gross appearance of bony mass removed at operation.

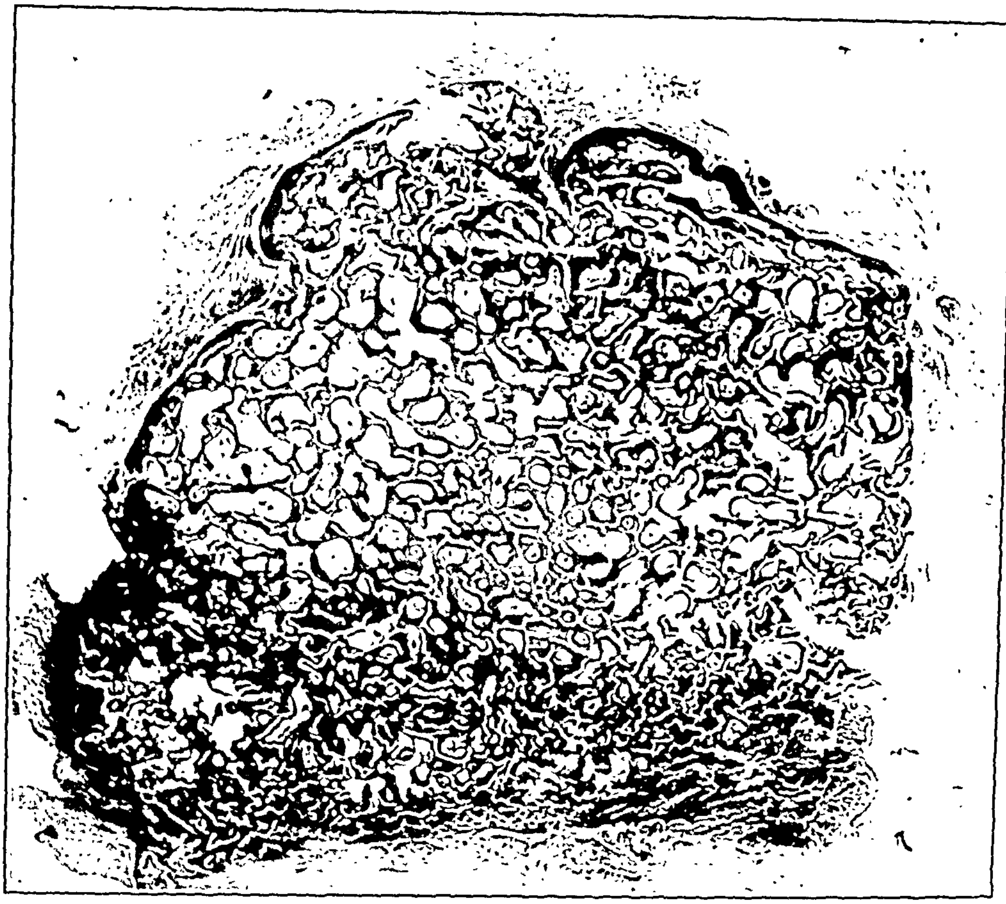

FIG. 4

Photomicrograph (low power) shows tissue removed to be normal cancellous bone.

plicated by a phlebitis which was easily controlled. The cast was not removed for six weeks.

Following the removal of the cast, physiotherapy, consisting of baking, massage, and stimulation with galvanic current, was instituted. After a few days active motion was encouraged. In approximately two weeks, the patient was actively flexing his knee again to 150 degrees and bearing weight without pain. He was discharged to the out-patient dispensary for further physiotherapy as the range of motion was rapidly increasing. After several visits he did not return for treatment. He reappeared after two months, having had no treatment, at which time examination showed motion to have increased satisfactorily. He was flexing his knee to 100 degrees with full extension. He was well pleased with the result.

FIG. 5

A. Anterior view. *B.* Lateral view. Photograph of the knee shows a slight flexion deformity and slight quadriceps atrophy, otherwise the gross appearance of the knee before operation showed nothing remarkable.

CONCLUSIONS

1. A case of tendinitis ossificans traumatica is reported. We believe that it was definitely due

to a proliferation of the periosteum resulting from trauma. This is a rare condition; only eight cases of similar nature have been reported. So far as we are able to learn the patellar tendon has not been the site of such a process in any of the reported cases.

2. Two cases of a rarer type, apparently due to an actual metamorphosis, have been reported.

3. In the proliferative type, surgical treatment to remove the mass, replace a functional mechanism, and prevent further proliferation is necessary. In the type due to a metamorphosis of tissue, simple excision only is indicated.

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FRACTURE OF THE ZYGOMA

BY OTHO C. HUDSON, M.D., HEMPSTEAD, LONG ISLAND, N. Y.

Fractures of the zygoma are usually associated with fractures of the malar bone. This fracture is given little space in the standard textbooks, and isolated cases have been reported from time to time.

Formerly the fractures of the zygomaticomalar arch were rare. However, with the advent of the automobile and airplane accidents its prevalence is increasing. The fracture is produced by a direct blow or fall on the zygomaticomalar arch. The injury occurs more frequently in the male.

The literature was reviewed and summarized by Roberts in 1928. Since that time few cases have been reported.

The treatment as a rule has been directed toward the malar bone which is depressed and associated with the fracture of the zygoma. Depressed malar fractures may be elevated as advocated by Roberts by a stab wound over the bone and elevation after fastening a special corkscrew-like instrument in the bone. Stacy advises a skin incision below the external canthus and then elevation with a periosteal elevator beneath the

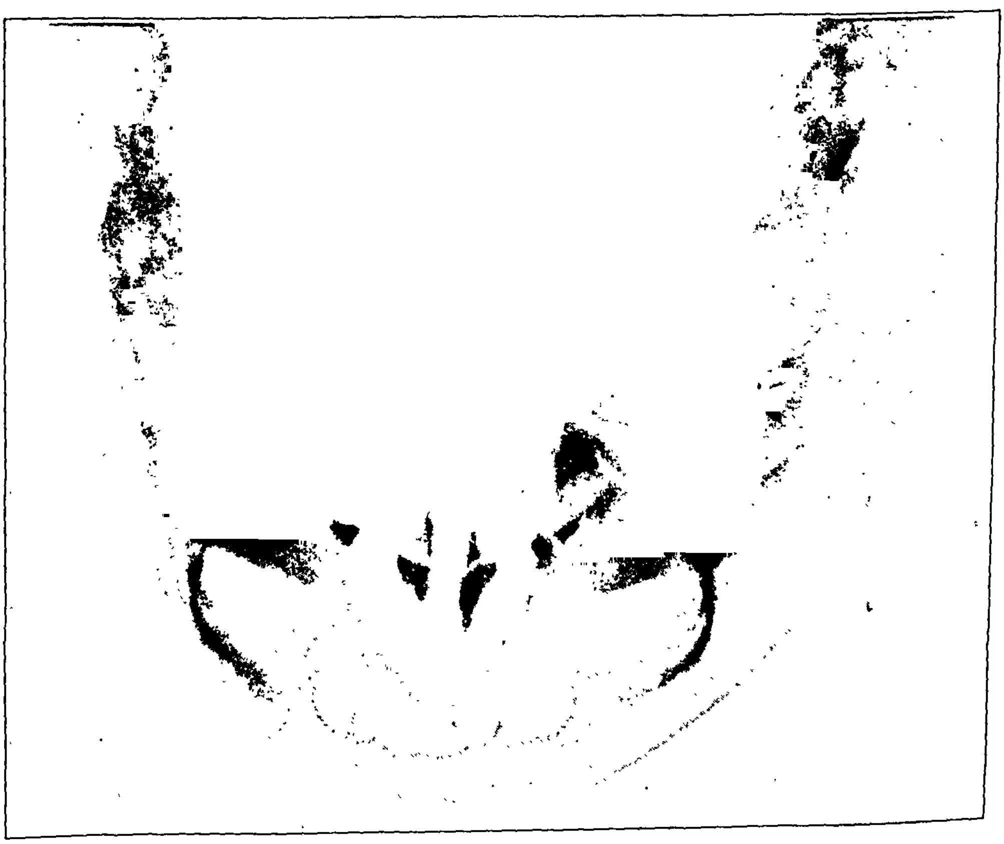

FIG. 1

X-ray showing depression of zygomaticomalar arch before operation (outlined).

malar bone. Wielage makes an incision in the mucous membrane within the mouth and elevates the bone with an elevator passed upward beneath the cheek. Opening the antrum from within the mouth and then elevating the depressed bone is used, but this method is more prone to infection.

The classical reduction of a fracture of the zygoma, as stated by Matas, is still useful. A long, full-curved Hagedorn needle threaded with silk as a carrier is made to penetrate the skin about one inch above the mid-point of the displaced fragment. The needle is carried well into the temporal fossa under the bone and then elevated so that the point of the needle emerges about one-half inch below the lower border of the broken bone. As the needle is pulled out, a strong silver wire is attached to the silk carrier and dragged through the track of the needle. The ends of the wire are twisted to form a loop upon which traction can be made upward until reduction is secured.

Fractures of the zygoma have also been reduced by open operation with incisions above or below the arch and elevation with an elevator.

Ivy and Curtis report a case where malunion of the zygomatic arch resulted in fixation of the lower jaw, due to callous and fibrous adhesions

FIG. 2

X-ray showing elevation of depression of zygomaticomalar arch (outlined)

FIG. 3

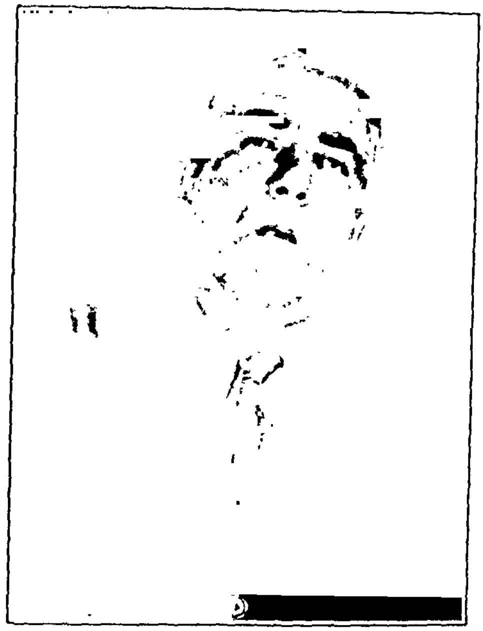

FIG. 4

Showing the depression and maximum amount which mouth could be opened previous to operation.

connecting the depressed zygomatic fragments with the coronoid process of the mandible.

Fracture of the coronoid process of the mandible can occur with these fractures.

The symptoms are pain in the region of the fracture, pain on movements of the jaw, difficulty of moving the jaw due to associated injury of the masseter muscle, depression of the face in front of the ear, crepitus, swelling of the face, and tenderness at the site of the fracture.

The diagnosis is made by examination and special x-rays to show the zygomaticomalar arch. Treatment should be instituted early, for union is rapid and may be clinically solid in ten to fourteen days.

We are reporting an isolated case of fracture of the zygomatic arch seen seven days after the accident. In this case union of the fragments was beginning and the jaw was fixed due to a mechanical bone block formed by the depressed fragments, so that the patient could not open his mouth.

The case report of G. U., aged forty-eight years, white, Polish.

This patient had been in perfectly good health all his life until January 19, 1932, when the wagon which he was driving was struck by a taxi, throwing him to the street. He landed on the right side of his face. He had immediate pain and disability in the face and could not open his mouth. He was unable to sleep on that side of his face or to touch the site of injury and had extreme pain on any attempt at chewing. When first seen he was living on a liquid diet. His chief complaint when seen on January 26, one week following the accident, was inability to open his mouth. Patient complained of some pain over the right temporomandibular joint.

An examination revealed a patient who was an elderly male adult in good general condition. His teeth were in fair condition. He was able to open his mouth for about one-fourth inch, but on doing this had pain in the right side of his face. There was swell-

FIG. 5

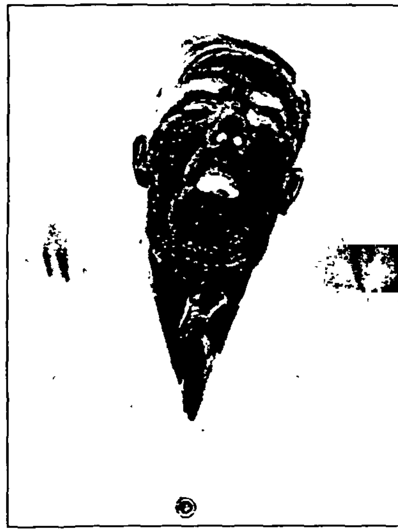

FIG. 6

Showing the end result with slight thickening at area of operation.

ing of the entire right side of the face and a considerable depression about midway between the ear and eye on the right. This depression was found to be along the zygoma. There was no depression of the malar bone in the region of the eye. Crepitus was not present over the depression. There was infiltration of all the muscles on the right side of the face. The left temporomandibular joint was not tender. Motion of the lower jaw was possible only for separation of the teeth for one-fourth of an inch.

An x-ray showed a comminuted fracture of the right zygomatic arch with marked depression of the fragments. X-rays of the right temporomandibular joint did not reveal any bony pathology.

The operation was done under two per cent. novocain infiltration of the skin and deeper structures. An incision about one inch long was made along the lower border of the zygoma. Branches of the facial nerve were isolated and retracted. The masseter muscle was split in line with its fibers. At open inspection it was found that the patient could not open his mouth because of a mechanical block made of the bony fragments lying immediately anterior and posterior to the coronoid process of the mandible. With an aneurysm needle the anterior fragments were elevated. Immediately afterward the patient could open his mouth about three-fourths of an inch. The posterior fragments were then elevated. Plain catgut was used to suture up the subcutaneous layer and dermal for the skin.

After the operation the patient had considerable swelling of the face and complained of numbness and tingling along the inferior maxilla. No sensory changes were noted however. The sutures were removed on the fourth day. At that time the patient was able to open his mouth so that his teeth were separated about one inch. Ten days after operation the patient said he felt normal and was able to chew and could open his mouth normally. If his mouth were kept open for a long period of time, however, pain was felt. The patient's face appeared normal except for a slight prominence in the middle of the zygoma due to overelevation of the middle fragment.

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MASSETER PARALYSIS IN ANTERIOR POLIOMYELITIS

TREATED BY A SPECIALLY CONSTRUCTED HELMET

CASE REPORT

BY MAURICE H. HERZMARK, M.D., NEW YORK, N. Y.

This case is being reported because of the unusual type of paralysis, and the unique method in which it was treated. In a series of thirty-six cases of recent anterior poliomyelitis, studied on the Service of Dr. Kleinberg, at the Hospital for Joint Diseases, New York, one case of bilateral paralysis of the masseter muscles was observed.

This case was seen in a child four years of age. The acute symptoms of the illness occurred in August, 1931, and paralysis set in shortly after the onset of the illness. While under observation at the Willard Parker Hospital, it was noted that the child had difficulty in swallowing, and there was paralysis of both lower extremities and the right upper extremity. On expiration of the quarantine period, the patient was transferred to the Hospital for Joint Diseases where he came under our observation.

Twenty days after the onset of the acute illness, on admission to the Hospital for Joint Diseases, the examination showed: a child in poor general condition, undernourished and underdeveloped; speech very much disturbed and almost incoherent; the muscles of the face very weak, especially the left facial. The mouth hung open and the ability to close it was lost except by approximating the lips without moving the lower jaw. The right sternomastoid muscle was paralyzed. When the jaws were closed passively the child was able to open them, but he could not close them even when the head was in the recumbent position. The right upper extremity, the abdominal muscles, and the muscles of the back were also paralyzed. Both lower extremities showed evidence of paralysis and weakness of many muscles.

FIG. 1

Front view of the plaster-of-Paris helmet and chin piece, showing the mouth held closed by means of elastic bands attached to hooks. Note the normal appearance of the lips.

FIG. 2

A side view, showing the hinge and the elastic band which holds the jaw closed.

FIG. 3

The mouth is open because of paralysis of the masseter muscles. The patient is unable to approximate the upper and lower teeth.

FIG. 4

The lips are approximated, but the jaw is in the same position as that shown in Fig. 3.

The problem of immobilization of the extremities, in order to prevent deformity, was quite simple; and, in accordance with the routine followed out in all recent anterior poliomyelitis cases, a plaster-of-Paris double hip spica and right shoulder spica were applied, holding the extremities in a neutral attitude. The problem of supporting the lower jaw, to prevent relaxation of the masseter muscles, presented some difficulty. Support of the jaw with bandages was unavailing, because they could not be held in place very satisfactorily. So a special plaster-of-Paris helmet was constructed, molding the plaster about the chin held firmly against the maxilla. This was then trimmed and hinged at the temporomandibular joint, and, by means of elastic bands, the chin piece was made to keep the jaws closed. This helmet functioned very satisfactorily, and the child was able to open his mouth against the slight resistance of the elastic bands, and to chew soft foods. The helmet was kept in place constantly, except when it was necessary to remove it for hygienic purposes. After two weeks, it was observed that on removal of the helmet, there was a slight return of power in the masseter muscles, so that the child could approximate his jaws. At the expiration of six weeks, the plaster-of-Paris spicas were removed, and the helmet was no longer needed.

An examination of this patient made five months after the onset of the paralysis showed complete recovery of the muscles controlling the face and jaws. There was also almost complete recovery of the other paralyzed muscles.

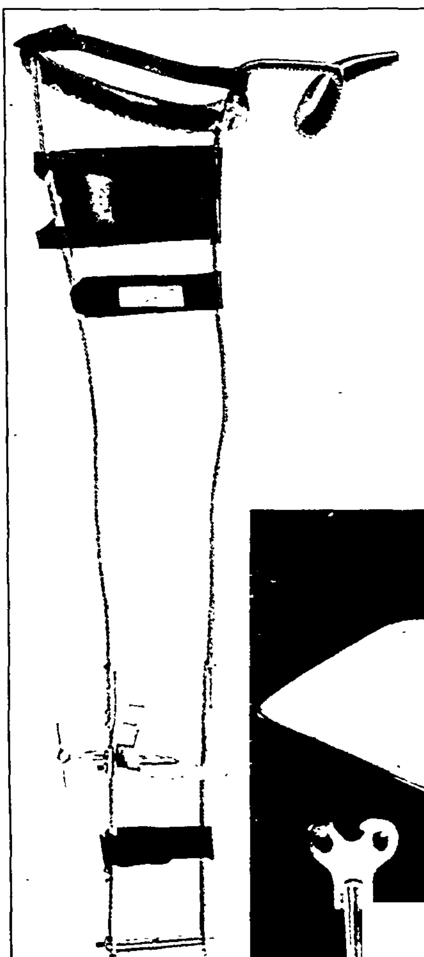
CONCLUSION

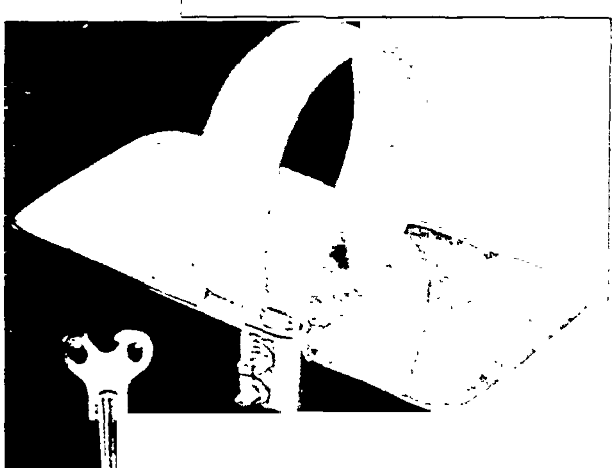
A case of bilateral paralysis of the masseter muscles, following anterior poliomyelitis, is reported to illustrate the support of these muscles by means of a specially constructed helmet made of plaster-of-Paris. This helmet may immobilize and support the lower jaw, without interfering with food intake. The quick return of power under this treatment is indicative of its value in alleviating so distressing a condition.

A FOOT PLATE FOR LEG SPLINT

BY THOMAS F. WHEELDON, A.M., M.D., F.A.C.S., RICHMOND, VIRGINIA

We have for a good many years used a great many Bradford abduction splints. The only objection which we have had to these splints has been the fact that it has been difficult to keep the foot at a right angle while supplying proper traction. After some consideration, the foot plate below illustrated was designed. A description of the plate further than the illustrations is unnecessary, except to state that it is made from rustless steel. It has the advantage of being easily moved up and down the splint, is interchangeable from right to left, is tightened on the splint with the same key which tightens the traction band of the splint, and allows support for the forefoot while still providing proper traction. The foot is comfortably held in place by a webbing band as illustrated. The plate can be used either in recumbency or after the patient has become ambulatory. The illustration shows the plate at a rather high level. This was done in order that its high range of position could be seen. The plate has now been in use for several years by us and we find it very practical and indispensable.





A NEW COMBINED SKIN ISOLATION CLIP AND RETRACTOR

BY G. KENNETH COONSE, M.D., COLUMBIA, MISSOURI

From the Department of Orthopaedic Surgery, University of Missouri

A satisfactory combined skin clip and retractor has been developed for operations on the femur and has proven extremely useful in other straight incisions of the extremities, back, abdomen, etc. For example, it can be used to excellent advantage in spinal fusion work. These clips are relatively inexpensive and have removable teeth (See illustration). It is possible to apply them quickly and easily by means of special clip "holders". After applying the clips in the usual way throughout the length of the incision, a long, flat piece of metal is slipped through the mid portion of the clips. The metal bar is somewhat smaller than the space within the clip, thus allowing a certain amount of motion upward and downward of the individual units. This is often of benefit when traction on a particular portion of the wound is required. Small metal balls are

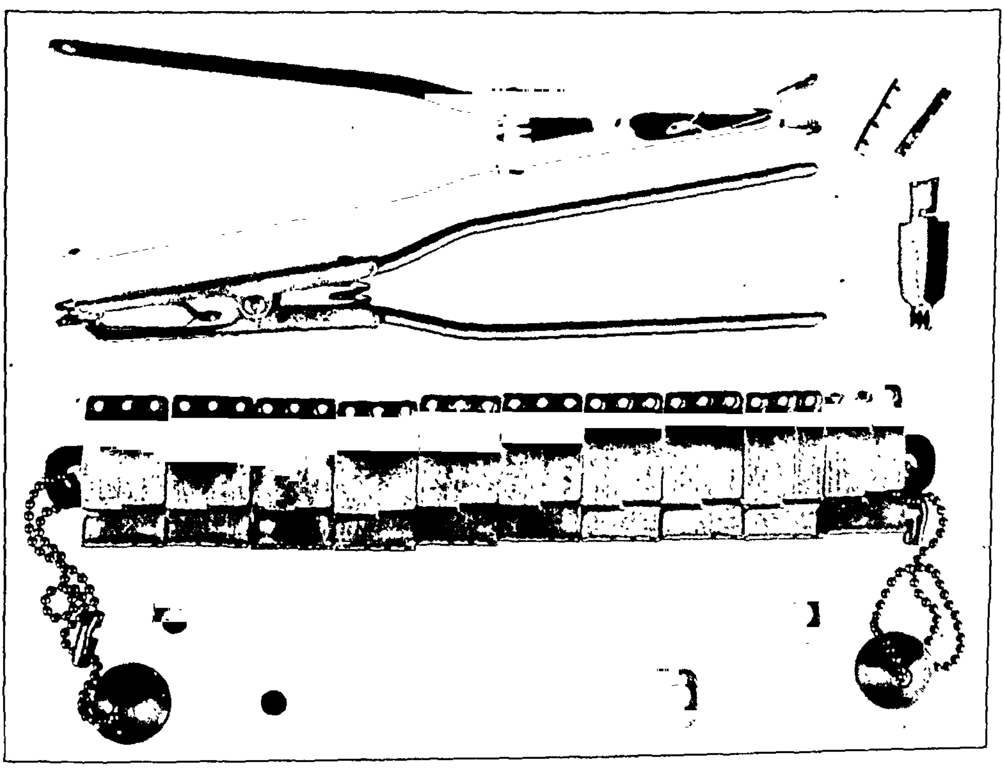


FIG. 1

The two instruments pictured are identical in make. The upper one shows a clip compressed in its distal portion and the lower one shows a clip being compressed medially, *i. e.*, close to the teeth. This is done to insure the teeth biting well into the skin and towel. They are removed by compressing the distal end of the clip. The removable teeth and clip are shown at the right-hand side of the illustration. Ten of them are shown at the lower portion of the picture with a metal rod and weights. Two additional rods of different lengths are shown in the lower part of the illustration.

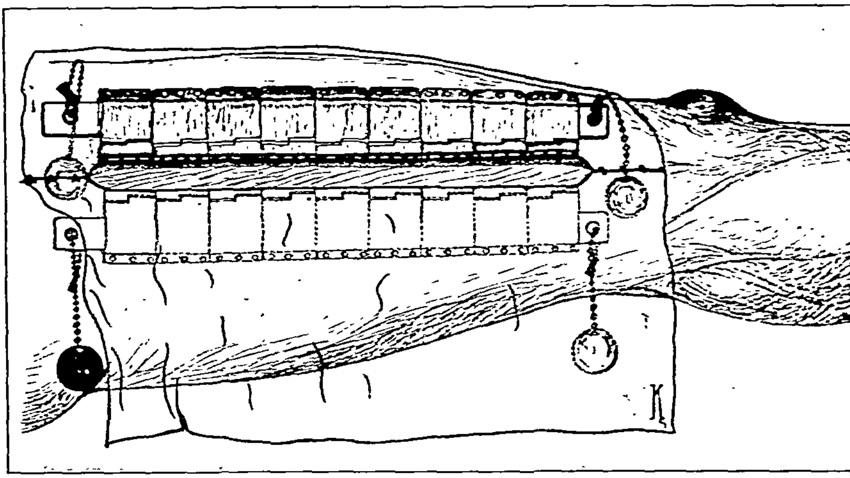


FIG. 2

Sketch of the clips in actual use in a leg-lengthening operation. The towels are pictured as if made of a transparent material. Details of the lower row of clips are not shown in order to simplify the drawing. Note that the metal balls are allowed to fall over both the medial and lateral sides of the leg. These provide even traction on the skin edges. The two towels are held together beyond the incision by Mischel clips.

suspended over either side of the incision (The lengths of the chains can be adjusted to suit the individual case) and serve to exert an even traction all along the wound. Any desired number of clips may be used, varying with the length of the incision in each particular case.

When rods of suitable length have been slipped into the middle of the clips, the clips and bars are turned backward as a unit (See Figure 2). Eversion of the skin edge is thus produced and a very complete isolation of the skin edges obtained. We have found them very helpful in retracting the skin edges during the operation and also in approximating the skin in suturing the wound.

These clips can be applied a great deal faster than Mischel clips or any other type with which we are familiar. In the illustration the towels are drawn as though made of transparent material in order to show the position of the clips, bars, and metal weights. Removal of the skin clips is equally simple. The metal bars are first pulled out: then, by means of the instrument shown in Figure 1, successive clips are removed.

This type of combined skin clip and retractor is reported because of its efficiency, simplicity, rapidity of application, and its relative inexpensiveness. The replaceable teeth are, as far as we know, a unique feature. This enables one to change them frequently at very little cost.

The writer wishes to acknowledge his indebtedness to Mr. Gus Tornsjo, Chief Technician, University of Missouri, for his help in the development of these special instruments.

CHOICE OF POSITION OF AXIS OF KNEE APPARATUS

BY JOHN JOSEPH NUTT, M.D., F.A.C.S., NEW YORK, N. Y.

In his admirable article on Flexion Contraction of the Knee in the July issue of *The Journal* (XIV, 618), Dr. Kulowski makes the statement: "It is absolutely essential that the joint remains the axis of motion of the system" (of the mechanical apparatus). This is difficult to accomplish in any joint, and in a compound joint well nigh impossible. It seems to me much safer to avoid the danger of interarticular pressure by moving the joint of the apparatus forward so as to have traction exerted on all the structures of the knee at the same time that extension is being forced.

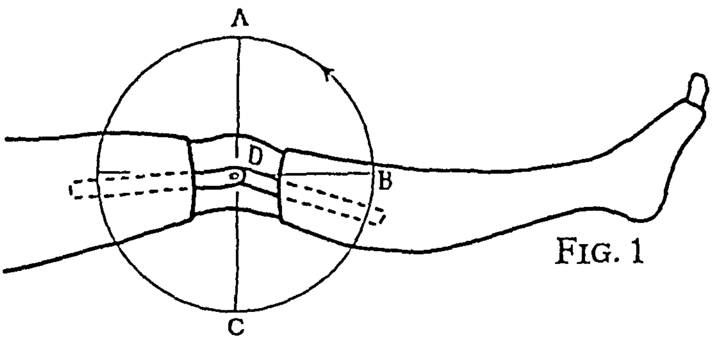


FIG. 1

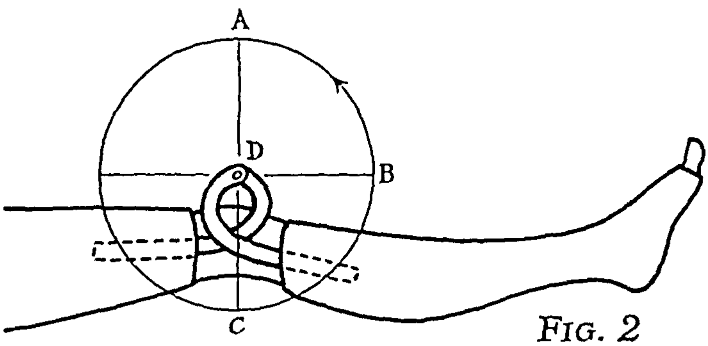


FIG. 2

This is easily done by continuing the lateral bars in elliptical curves and jointing them where they meet—in the horizontal plane of the anatomical axis. Figure 1 shows the direction of the movement about the axis of the apparatus in the above cited article. It is evident that in the quadrant BDC the movement is downward as well as forward, while in the quadrant ADB the movement is upward as well as forward. By changing the axis of rotation, D, to a point anterior to the knee, as in Figure 2, we have all the knee structures in the quadrant BDC and all the force exerted in a downward and forward direction with no danger of interarticular pressure.

In children, where the lever arms are short, it may be necessary for the bars to pass each other twice in order that their joint may be brought close to the anterior part of the knee.

A SANDAL FOR THE PREVENTION OF FOOT-DROP FOR USE WITH TRACTION-SUSPENSION APPARATUS *

BY CORNELIUS J. KRAISSL, M.D., NEW YORK, N. Y.

The use of a light-weight leather sandal, designed by the writer, has obviated many of the annoyances heretofore experienced with the adhesive, "mole skin", or light plaster formerly used to hold the foot in slight dorsiflexion for the prevention of foot-drop in cases requiring traction-suspension apparatus.

The sandal consists of four main pieces of leather as indicated in the diagram. The sole is pliable but more firm than the other parts. It is extended well beyond the toes and an elongated strip is left for fastening a ring to which the suspension cord will be attached. The heel piece is made of very soft, seamless leather, preferably lined with chamois, and is cut to fit the heel snugly. It is fastened over the dorsum of the foot with laces. A chamois tongue is attached just inside of the eyelets for the purpose of protecting the skin. Two wide, soft leather bands are secured to the front of the sandal and are laced in similar manner across the

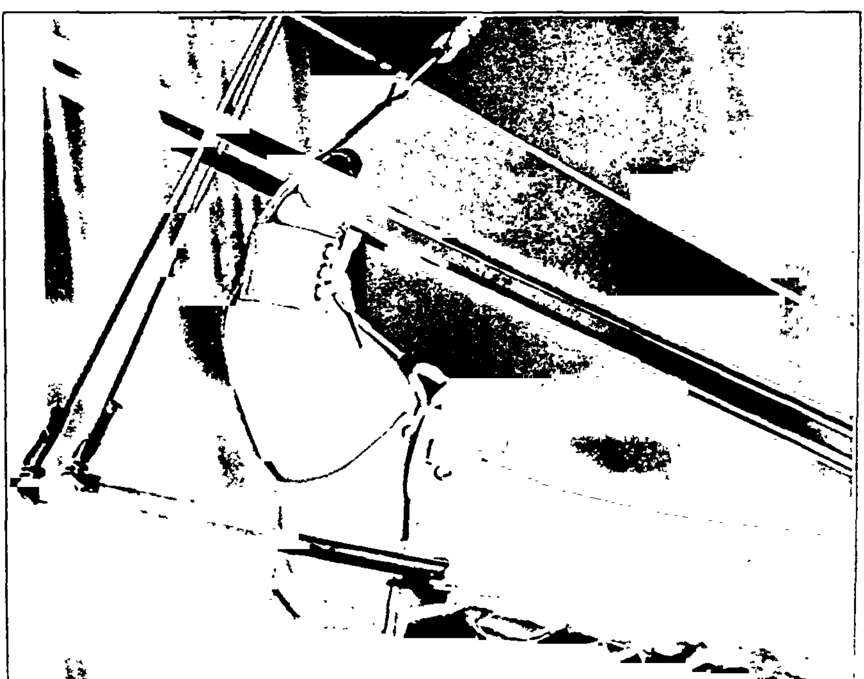


FIG. 1

Lateral view.

* From the Fracture Service, Presbyterian Hospital in the City of New York.

metatarsal region. The skin here is also protected by a similar chamois tongue. These pieces are sewed to the sole or may be laced to it by a leather thong if small holes are punched along corresponding margins.

Sandals, which are constructed in the three sizes indicated at the left of the diagram, will adapt themselves to nearly all sizes and shapes of feet and may be used *interchangeably on either foot. Variations in the design*, however, may prove to be of advantage where the foot shows some abnormality,—such as exostoses, requiring a wider sole piece, or a slanting heel, necessitating seams in the side of the heel piece. Lacing the heel piece on the side may insure a more perfect fit in some cases where there is a very marked curve of the heel toward the tendo achillis.

This type of appliance has proved more satisfactory than other methods of foot support for use with traction-suspension because of the following features:

(1). The increasing use of pin traction in the treatment of fractures, associated with early and continued active motion, com-

FIG. 2
Dorsal view.

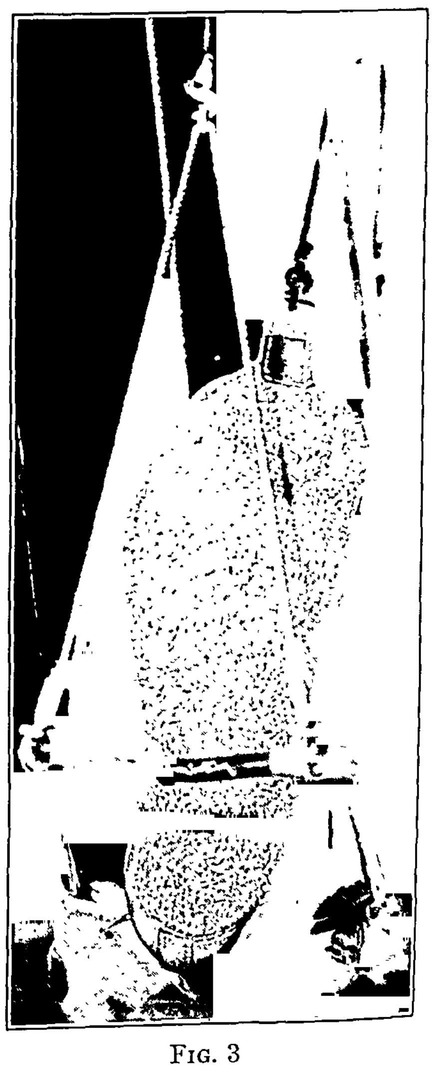


FIG. 3
Plantar view.

Small Size	
AB	26 cm.
CD	9 cm.
EF	6 cm.
GH	24 cm.
IJ	4 cm.
KL	4 cm.

Medium Size	
AB	29 cm.
CD	10 cm.
EF	7 cm.
GH	28 cm.
IJ	5 cm.
KL	4 cm.

Large Size	
AB	35 cm.
CD	12 cm.
EF	8 cm.
GH	34 cm.
IJ	7 cm.
KL	6 cm.

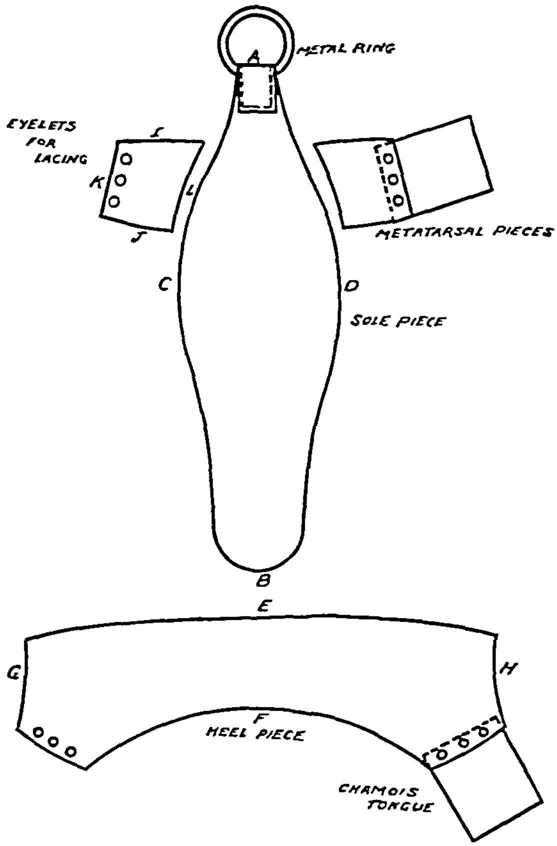


Fig. 4
Working drawing of a typical sandal.

bined with physiotherapy, soon causes adhesive to loosen and require reapplication, and each reapplication of adhesive is more detrimental to the skin.

(2). The sandal may be removed by a nurse, the foot cleansed, and the sandal reapplied with perfect safety, insuring a healthy condition of the skin.

(3). The sandal is easily applied, and one is assured of its stability.

(4). The appliance may be used over long periods of time with minimum discomfort to the patient. The photographs were taken of the sandal being worn by a patient for a period of sixty days. S complained of practically no discomfort during this entire time.

(5). The sandals are easy to make. They may be supplied a brace-maker at a cost of $2.50 apiece.

If expense is an item, the Occupational Therapy Departmen may prove to be a valuable adjunct. At the Presbyterian Hospital this department supplies the convalescent patients with the leather, patterns, and a few tools for punching holes and inserting the eyelets. In this way a perfectly satisfactory article has been produced for about sixty cents and in addition provides useful diversional therapy for these patients.

News Notes

Just as *The Journal* goes to press, word has been received of the death of Dr. Russe A. Hibbs in New York on September 16. A tribute to the service of Dr. Hibbs will appea in the January issue.

Word has also been received of the death of Dr. Nathaniel Allison at La Jolla, Cali fornia, on August 30. Further notice concerning Dr. Allison will be published in the nex number of *The Journal*.

With deep regret *The Journal* announces the death of Docent Dr. Otakar Schulz o Prague, who died on June 4. Dr. Schulz was President of the Czechoslovakian Ortho paedic Society, Medical Director of the Jedlička Institution for the care of crippled children, and one of the outstanding orthopaedic surgeons of his country.

The Annual Roll Call of the American Red Cross to enroll members for 1933 will be held from Armistice Day to Thanksgiving Day, November 11 to 24.

Docent Dr. Zahradniček has been made head of the Orthopaedic Clinic of University Karlovy at Prague, succeeding Prof. Stanislav Tobiášek who died last November.

Dr. Robert V. Funston, formerly of Detroit, Michigan, is now located at University, Virginia, and has been made Professor of Orthopaedic Surgery of the University of Virginia at Charlottesville.

Dr. Vernon L. Hart, formerly of the Department of Surgery at the University Hospital, Ann Arbor, Michigan, has recently become associated with the Dayton Clinic, Dayton, Ohio. He is in charge of the Orthopaedic Service of the Clinic.

At the Congress of the **Deutsche Orthopädische Gesellschaft** at Mannheim, Dr. Arthur Steindler, President of the American Orthopaedic Association, was elected a Corresponding Member; and the Editor of *The Journal* was made an Honorary Member.

The good will and the assets of William Wood and Company of New York have been purchased by the Williams and Wilkins Company of Baltimore. William Wood and Company is one of the oldest medical publishing houses in the country, having been established in 1804 by Samuel Wood.

A symposium on dental caries was held in Pittsburgh, Pennsylvania, on June 23, under the auspices of the International Association for Dental Research. The proceedings of this symposium were published in the August issue of the *Journal of Dental Research*, and reprints may be obtained upon request to the Mellon Institute of Industrial Research, Pittsburgh.

The Aid Association of the **Philadelphia County Medical Society** is establishing a Perpetual Memorial Fund in honor of Dr. John B. Deaver. The income from this fund will be used to afford aid to needy physicians and their families. Those who desire to contribute to such a fund should communicate with Dr. Francis Heed Adler, Secretary, 313 South 17th Street, Philadelphia, Pa.

At the Executive Committee Meeting of the **British Orthopaedic Association**, held June 21, the following were elected Associate Members:

Grant Massie, Esq., 55, Wimpole Street, London, W. 1.
Philip Wiles, Esq., 90a, Harley Street, London, W. 1.
E. A. Freeman, Esq., 56, Waterloo Road, Wolverhampton.
P. E. Glynn, Esq., Royal National Orthopaedic Hospital, Great Portland Street, London, W. 1.
E. N. Wardle, Esq., Sheildaig, Oakfield Road, Heswall, Cheshire.

The Second Congress of the International Society of Orthopaedic Surgery will be held in London July 19 to 22, 1933. The officers are:

President:	Prof. Nové-Josserand, Lyons, France.
Vice-Presidents:	Prof. Murk Jansen, Leiden, Holland.
	Prof. Gocht, Berlin, Germany.
	Prof. Vittorio Putti, Bologna, Italy.
Secretary General:	Dr. Delchef, Brussels, Belgium.
Secretary:	Mr. Harry Platt, Manchester, England.
Treasurer:	Prof. Maffei, Brussels, Belgium.

The sessions will be held at the Royal Society of Medicine and the program includes the following:

Wednesday, July 19, 1933.
2 P.M. Reunion of the International Committee.
4.30 P.M. General Assembly.
8.30 P.M. Reception by the President.

Thursday, July 20, 1933.
9.45 A.M. Presidential Address.
10.30 A.M. Mechanism of Articular Movements in General.
Prof. H. von Baeyer, Heidelberg, Germany.
Prof. Riccardo Dalla Vedova, Rome, Italy.
Prof. Richard Scherb, Zürich, Switzerland.
2.30 to 5.30 P.M. Operative Clinics.
6.30 P.M. Reception by the Royal College of Surgeons.

Friday, July 21, 1933.
9 A.M. Treatment of Tuberculosis of the Hip.
Prof. Philipp Erlacher, Graz, Austria.
Dr. Maffei, Brussels, Belgium.
Dr. Melvin S. Henderson, Rochester, Minnesota, U. S. A.
Dr. E. Sorrel, Paris, France.
2.30 P.M. to 5.30 P.M. Operative Clinics.
7.45 P.M. Banquet.

Saturday, July 22, 1933.
2 P.M. Visit to the Orthopaedic Hospital of Alton.

The British Orthopaedic Association had a one-day meeting in London on July 27, 1932, under the presidency of Mr. A. S. Blundell Bankart.

In the morning, Dr. Max Böhm, of Berlin, read a paper on "Infantile Deformities". Ten years' research work had convinced him that the common deformities—such as pes valgus, pes planus, genu varum, genu valgum, genu recurvatum—are not due, according to popular belief, to static disorders, but to an arrested development; the deformity being, in every case, the condition normally met with in the foetus and in the anthropoid.

Mr. Blundell Bankart gave an address on "Chronic Tuberculous Osteomyelitis of the Ilium, Involving the Hip Joint". He said he had been endeavoring, by means of a formidable operation, to remove all the diseased area; this implied a resection of the head

and part of the neck of the femur, of the acetabulum, and of the acetabular-bearing portion of the ilium. The result is a painless, stable pseudarthrosis.

Prof. Vittorio Putti, of Bologna, Italy, read a paper on the "Abduction Method of Treating Congenital Dislocation of the Hip in Young Infants", and summarized his experiences with the method.

The afternoon session was devoted to a clinical demonstration by the President, Mr. Blundell Bunkhart.

The Twenty-Seventh Congress of the Deutsche Orthopädische Gesellschaft was held in Mannheim on September 5, 6, and 7, under the presidency of Dr. Adolf Stoffel, with an attendance of about 450 members and guests. In accordance with the custom of the Society the preceding evening was devoted to the *Begrüssung Abend*, allowing to the members the opportunity of meeting together before the opening of the scientific part of the program.

In the scientific meetings, four principal subjects were considered,—Fracture of the Neck of the Femur, Operation for Remodelling the Acetabulum, Internal Injuries to the Knee Joint, and Treatment of Malunited and Ununited Fractures.

The papers and discussions on the first subject were directed mainly toward the question of the treatment, either by fixation in plaster-of-Paris, or by operation. The concurrence of opinions was distinctly in favor of the treatment by plaster, and the method of Whitman was generally used. In the treatment of the old ununited cases, the operative procedure by means of the bone graft was preferred by the large majority of the speakers; but one used a metal peg. The discussion distinctly brought out the need of long continued treatment and observation because of the danger of late necrosis and subsequent yielding at the point of reunion. Observation over a period of eighteen months was considered advisable.

In the operation for remodelling the acetabulum, the breaking down of a portion of the outer table of the acetabular cavity, and the roofing operation were mainly considered, and, in general, the producing of a projecting area of bone by some one of the various methods for impingement of the head of the femur was preferred. It was also brought out that, in establishing some form of bone impingement, it is not sufficient to rely alone upon the bone projection; but, to insure security, it is necessary to transplant downward the trochanter with its muscular attachments. Mobilization must begin early,—at least within two weeks.

On the subject of internal injuries to the knee joint, rupture of the crucial ligaments, and injury to the meniscus were the main topics considered. One remarkable series of sixty-nine cases, operated upon by one surgeon and with a satisfactory percentage of successful results, was presented. In the discussion of the methods of operation for repair of the crucial ligament, several cases of suture of the anterior to the posterior ligament with good results were reported. The opinions were equally divided between the removal of the entire meniscus and of the injured portion only. The incision most frequently used was the long longitudinal incision of Payr. The time allowed for full convalescence varied very considerably among the different surgeons.

In the part of the program devoted to the subject of malunited and ununited fractures a large number of the various types and cases were shown, and the individual methods and techniques of dealing with these were demonstrated. The uniformity of the problem to all surgeons dealing with traumative surgical conditions was evident. The method—sometimes referred to as the American system—of dealing with the compensation of the industrial cases by cash settlement was advocated by some surgeons, but also it was emphasized that the necessary operation for the special case should precede the settlement. The discussion on the social aspect also showed that the same difficulties are encountered by all surgeons and in all countries.

The next meeting will be held in 1933 in Leipzig, under the presidency of Dr. Schede.

Current Literature

MANIPULATIVE SURGERY. By A. S. Blundell Bankart. M.A., M.Ch. (Cantab.), F.R.C.S., London, Constable and Company, Ltd.. 1932. 7/6 net.

In presenting this small volume on manipulative surgery, Bankart has rendered a real service. This country is overpopulated with those ready to capitalize the failures of surgeons to recognize the value of this branch of their therapeutic armamentorium. The "natural bone-setter" is by no means the only one to profit by the failure of the medical profession to cultivate this field. Physicians should make themselves acquainted with the lesions amenable to this line of treatment as well as with the technique of their management.

In the introductory chapter is a clear presentation of what constitutes a sprain and what are the physiological indications for its treatment. A few paragraphs—the most significant in the chapter—are devoted to Sherrington's studies on what he terms "postural" muscular action and "phasic" muscular action, upon an understanding and acceptance of which hinges the whole art of manipulative procedure. This part of the discussion should be thoroughly mastered. Very sound advice is given as to the selection of cases for manipulation. The reasons for failure are outlined and suggestions offered as to the pathological features of the chronic non-tuberculous arthritides which are sane and sound. Emphasis is laid on the fact that, unless one is prepared to carry out what is erroneously termed the "after treatment", one has no right to undertake the initial manipulation. The importance of full surgical anaesthesia is urged.

In the chapter on the foot is a clear presentation of the author's ideas of the causation of "weak" or "flat-foot" and the type of treatment appropriate to the different grades of this trouble. It is an admirable discussion of the subject which is particularly valuable to American orthopaedic surgeons committed to the get-relief-quickly methods of treatment. "Anterior metatarsalgia" or,—as we know it here in America—"Morton's toe", is regarded as a "traumatic arthritis" of some of the outer metatarsophalangeal joints, which is a theory having less to support it than Morton's explanation does.

In a chapter on the knee, "internal derangements" of this joint are well discussed and the application of manipulative measures for their treatment is outlined. Among other subjects discussed he gives a paragraph to the synovial folds in the anterior part of the joint that are occasionally pinched, causing symptoms not unlike semilunar cartilage displacements.

A short discussion of hip manipulation leads up to chapters on "Sprains of Muscles and Tendons in the Lower Extremity", "The Spine and Pelvis", "The Fingers, Hand, and Wrist", "The Elbow", "The Shoulder", and a chapter on "Bone-Setting and Osteopathy".

A chapter summarizing what has gone before and an appendix upon the sub-astragaloid and mediotarsal joints closes this most instructive contribution to our knowledge of manipulative surgery, an appreciation of which will go far to counteract the influence of the "cults".

RÖNTGENDIAGNOSTIK DER KNOCHENVERLETZUNGEN. By Dr. Fritz Schnek. Vienna. Wilhelm Maudrich, 1932.

This book, consisting of 333 pages and containing 389 illustrations, is the result of a wide experience of the author in the treatment of bone injuries, under the direction of Dr. Lorenz Böhler. The latter, in a foreword, very appropriately emphasizes the need of such a work. In producing this volume the author has set out to answer a

number of questions pertaining to diagnosis and treatment of fractures. Among these are the following: Is a displacement present which demands a correction of position? When is a control examination to be undertaken? When the fragments are displaced, is the displacement which will eventually be present significant for function? Is the reduction anatomically correct? In what position has healing occurred? What can be said regarding the length of time required for healing? Is the formation of callus progressing normally? Has sufficient bony union taken place to permit weight-bearing? Are changes present in the bone or soft tissues, which give any indication of future function? Is there a disturbance of callus formation, or a pseudarthrosis?

In answering these and many other questions relative to bone injuries, several chapters are devoted to general considerations of diagnosis. Thus there are discussions on problems of the roentgen examination, technical procedures, the observation and analysis of the roentgenogram, the control examination, the diagnosis of the fracture, normal callus formation, disturbance of callus formation, bone atrophy in healing of fractures, and arthritis deformans.

In the special portion of this book are found descriptions of the various types of fractures occurring in the upper extremity, the lower extremity, the skull, and the spine.

The reader will be impressed with the simple, but thorough and systematic style of writing employed by the author in presenting his subject. This is supplemented amply by illustrations which are helpful and instructive. The material contained in this volume is written entirely from the experience of the author and includes only a few references to other works. Attention is called to many points which are easily overlooked. The conviction and authority with which the author expresses himself are undoubtedly the results of the unusual opportunities which he has had to observe bone injuries. This book will be a valuable asset to the roentgenologist and to the surgeon. It may be stated that some portions of this work are somewhat mystifying, as a result of the particular type of treatment employed, and for this reason the principles which are advocated will have a stronger appeal to the reader who is familiar with the author's therapeutic methods.

ORTHOPAEDIC SURGERY. By Walter Mercer, M.B., Ch.B., F.R.C.S. (Edin.), F.R.S. (Edin.). With a Foreword by John Fraser, M.C., M.D., Ch.M., F.R.C.S.E. London, Edward Arnold and Co., 1932. 32/6 net.

In this new Orthopaedic Surgery of Mercer's, the publishers have given us a well printed, single-volume work of 659 pages, thoroughly indexed and accompanied by a classified bibliography at the end of the text and not encumbering it. The style is clear and the illustrations are for the most part excellent, though some of the x-ray reproductions are not as good as is desirable. The entire field of orthopaedic surgery is covered in a way which will serve the needs of a general practitioner or a surgeon admirably. It has been written by a general surgeon of wide experience who has found his particular interest in the problems of the orthopaedic specialist. Such is the proper evolution of a specialist in any surgical branch and perhaps this is particularly true of the field with which this volume deals.

ARTHRITIS DEFORMANS UND CHRONISCHE GELENKKRANKHEITEN. By Prof. Dr. Hans Burckhardt. Neue Deutsche Chirurgie, LII. Edited by H. Küttner. Stuttgart, Ferdinand Enke, 1932. 55.50 marks.

In this work the author has undertaken the task of demonstrating the different features of arthritis deformans as a clinical entity, and also as a disease picture playing an important rôle in the course of many chronic joint ailments. From his conception of arthritis deformans, the author mentions the characteristics of this condition and discusses it in its relation to the joint changes occurring in various other joint diseases.

Beginning with a description of the anatomical and physiological features of joints, the author proceeds to a consideration of all the component structures in their pathological state. This is followed by a detailed description of the histological characteristics of all the tissues involved in arthritis deformans. Among other conditions to be discussed are joint mice, injuries to the meniscus of the knee, and chondropathy. Attention is then directed to the group of epiphyseomalacias, including Perthes' osteochondritis deformans juvenilis, Köhler's disease of the heads of the metatarsals, Kienböck's disease of the carpal lunate, and Köhler's disease of the tarsal scaphoid. There are, further, discussions of coxa vara, coxa valga, fracture of the neck of the femur, regenerative processes (pseudarthrosis, nearthrosis, and arthroplasty), neuropathic joint diseases, hemophilia, and chondromatosis.

The most important portions of this work are, of course, the descriptions of articular rheumatism (polyarthritis rheumatica) and arthritis deformans. These two conditions are treated separately, and in a detailed and thorough manner. Among the other chronic joint ailments which are mentioned and discussed at varying length are the arthritides associated with gonorrhoea, syphilis, tuberculosis, leprosy, gout, ochronosis, psoriasis, Raynaud's disease, Gaucher's disease, osteophytosis and osteitis deformans.

In all the more important conditions, there is a detailed discussion of the etiology, pathology, symptomatology, diagnosis, and treatment. Description of treatment is, however, frequently restricted to a brief mention of the indications, the technical details being omitted. One chapter, devoted to treatment of joint ailments, enumerates the different methods, local and general, of conservative therapy, and describes briefly several operative procedures which have been found to be efficacious in joint disease.

The bibliography comprises thirty-eight pages and in this the references are more complete than is usually the case. The illustrations, seventy in number, are clear, instructive, and well chosen, but might be more numerous.

The most important and impressive feature of this book is the thoroughness shown in the description of pathological tissues. This work should be of real assistance to any student of chronic joint diseases.

FUNGOUS DISEASES. A Clinico-Mycological Text. By Harry P. Jacobson, M.D. (With introductions by Jay Frank Schamberg, M.D. and Howard Morrow, M.D.) Springfield, Illinois, Charles C. Thomas, 1932. $5.50.

The aim of the author has been to "make available to medical students and practitioners a comprehensive, concise, and readable discussion of the subject of clinical mycology" and he has succeeded admirably. The book considers briefly the elements of mycology with enough of the fundamentals to enable a student without the expenditure of unnecessary time to begin and continue intelligently the study of fungous diseases. It considers the dermatomycoses, about which so much is being written, and follows with discussions of the fungous diseases which, in addition to the skin, may affect the viscera, bones, and cerebrospinal system. Of these it describes and discusses sporotrichosis, blastomycosis, actinomycosis, and coccidioides or so called California disease (which is considerably more widespread than this name would imply. All of these may be serious and intractable infections of interest to those doing surgery as well as to dermatologists and internists.

A feature which adds to the pleasure and profit in reading this book is the historical summary with which each chapter is provided, and there is an excellent bibliography appended.

Such criticism as the book will have may fairly come, we believe, from the mycologists. The whole subject of classification in medical mycology is in a rather chaotic state at the present time and simplification is a necessity. Such classifications as the author has adopted do not take advantage of simplifications which are already

sufficiently well founded and which should at least be included in a book of this sort. Such omissions can be included in future editions, which will undoubtedly be called for. There is no similar book in English and undoubtedly it will be much used, particularly by medical students.

The volume itself is an excellent example of good book-making and the illustrations are numerous and illuminating.

FRACTURES. By Meurice Sinclair, C.M.G., M.B., B.Ch. (Edin.). With an Introduction by Sir Robert Jones, Bt., K.B.E., C.B., F.R.C.S. London, Constable and Company Ltd., 1931. 24 shillings net.

Sir Robert Jones writes an introduction calling attention to the memorable service of Major Sinclair at the front in the Great War. Major Sinclair conducted a Fracture Hospital and the results of treatment at this hospital were a great tribute to his devotion and ability.

The book is in two parts and contains an exposition of Major Sinclair's own technique and experience during the past sixteen years. General Considerations occupy 225 pages and Individual Fractures, 312 pages.

The author believes that three cardinal principles govern the treatment of every fracture: (1) prevention of further injury; (2) replacement of damaged parts into normal axial alignment; (3) restoration of function. The technique followed by Major Sinclair is described and it is rightfully insisted that this technique must be faithfully followed if results are to be obtained by it. The Sinclair skate, the malleolar caliper, the supracalcaneal stirrup, the universal suspension frame, the net bed, the Thomas splint and its various attachments, the arm splint, the abduction cushion, the forearm splint, the racket splint are described. These have all been devised by Major Sinclair. He prefers to hold a fracture by wire when possible instead of by a steel plate and screws. Immobilization, extension, and suspension are insisted upon and are to be employed when indicated.

The value of this book lies in the presentation of Major Sinclair's personal experiences in a very extensive practice in treating fractures. The book is a clear, concise statement of one man's treatment of fractures, together with the fundamental principles involved. Argumentative excursions are absent.

KÜNSTLICHE GLIEDER. HEFT 1. UNTERE EXTREMITÄTEN. (Artificial Limbs. Volume I. The Lower Extremities.) By Dr. Friedrich Mommsen and Dr. Kurt Büchert. Stuttgart, Ferdinand Enke (Beilageheft zur *Ztscher. f. Orthop. Chir.* LVI), 1932. 8 marks.

A wealth of ingenious and new ideas have been developed in the construction of artificial limbs since the World War. Samples, models, and drawings of prostheses have been collected at the Oskar-Helene-Heim in Berlin. With this material as a nucleus, representative artificial legs from all of the world and particularly Germany are presented in this first volume of one hundred and twenty pages. Detailed drawings of sixty different types are given, with brief mention of their outstanding features. There are legs so simple that they sacrifice grace of locomotion, and others so complicated that they are discarded as cumbersome. But here is a collection of applied mechanical principles that will furnish inspiration to any surgeon or limb-maker who is looking for a different way of solving an unusual problem.

THE LABORATORY IN SURGICAL PRACTICE. By E. C. Dodds, M.V.O., M.D., and Lionel E. H. Whitby, C.V.O., M.D. (Camb.), M.R.C.P. (London), D.P.H. London, Constable and Company, Ltd., 1931. 8/6 net.

The need for preoperative study of prospective surgical cases cannot have too

much emphasis. Hence a test that is practical for the surgeon, in that it clearly defines the need for routine valuation of operative risks, even where they seem good on the surface, is a valuable book. The minimal hemoglobin index and the red count which is a contra-indication for operative work should be borne in mind. Leukocytosis, its limits, and the causes for its variation, as well as the condition in which its determination is of special importance, must be considered, and so on with sputum, feces, urine, infections, and coagulation time, etc. So much help is obtained these days from blood transfusions that a full chapter is devoted to methods of determining the compatibility of donor and recipient and the interpretation of the agglutinative reactions. Serum therapy as an adjunct of operative surgery and the employment of vaccines, bacteriophages, and serums, and the ways of avoiding allergic reactions receive adequate consideration. A chapter on the association of pregnancy and diseases—such as diabetes, jaundice, osteitis fibrosa cystica, etc.—in patients upon whom some postponable operation is contemplated receives merited discussion. Two chapters are allotted to the clinical examination of the urine, stressing the importance of bedside investigations and pointing out the value of further laboratory study where certain specific matters require a solution. Questions of the integrity of renal function are important.

In describing tests appropriate to the investigation of gastro-intestinal diseases, a full discussion of the Ewald and fractional test meals is given. Also the value of certain of these tests in determining the potency of gastro-enterostomy stomata is pointed out. The diagnosis of certain diseases of the pancreas from other abdominal conditions may be helped by a study of the digestion of starches by the pancreatic diastase, which is normally poured into the intestine when the pancreatic duct is not obstructed. In respect to tests of liver function, the author passes over the very numerous tests described in the literature and cites two relating to the determination of the icterus index and the global functioning capacity of the liver. Intravenous cholecystography is described as it has been developed; its uses and dangers indicated. The fact that four-fifths of the liver may be destroyed without causing any symptoms, but if the other fifth is taken away, violent convulsions occur unless intravenous glucose is administered, makes it appear that tests of functioning capacity are of little value in estimating the amount of liver tissue destroyed. A chapter is devoted to a discussion of the value of basal metabolism as applied to the study of thyroid cases. The last three chapters are concerned with the significance of exudates and transudates in the bacteriological, chemical, and biochemical tests of value in the study of effusions in the chest, abdomen, and articular cavities, together with detailed descriptions of these various tests and the technique of their application, especially in the case of blood-urea and alkali reserve.

Die Unspezifischen Chronischen Erkrankungen der Wirbelsäule. By Prof. Dr. Hans Burckhardt. Stuttgart, Ferdinand Enke, 1932. 50 marks.

This booklet consists of seventy-four pages and contains twenty-two illustrations. It was originally intended to form a part of the volume on "Arthritis Deformans und Chronische Gelenkkrankheiten" but, for various reasons, has been published as a separate work. The subjects under consideration in this volume are anatomy of the spine, Schmorl's "Knorpelknötchen," Scheuermann's disease (round back), fish vertebrae, degeneration of the intervertebral discs, Calvé's disease, fracture of the spine, Kümmell's disease, spondylitis deformans, spondylitis ankylopoetica, rheumatic spondylitis, inflammations, neuropathies, and spondylolisthesis. These subjects are discussed in the same manner as the diseases in the volume mentioned above. The material is limited to a description of conditions which are related to arthritis deformans or to chronic joint ailments.

THE SIGN OF BABINSKI. A STUDY OF THE EVOLUTION OF CORTICAL DOMINANCE IN PRIMATES. By John F. Fulton and Allen D. Keller. Springfield, Illinois, Charles C. Thomas, 1932. $5.00.

This monograph deals with the nature and significance of the sign of Babinski from a study of this and other pathological reflexes in the higher primates. In the order of cortical development the animals used were the monkey, baboon, gibbon, and chimpanzee. In the lower vertebrates, as the dog and cat, only crude homologues of the normal plantar and Babinski reflexes were found, and the authors hold that the Babinski phenomenon is essentially a problem of the primate foot. In the higher primates used the normal plantar reflexes were found absent or predominantly flexor in type.

In the experimental studies the animals were subjected to damage to some portion of the pyramidal pathways, such as complete cord transection, cord semisection, ablation of one or both foot areas, and complete removal of a single hemisphere.

In the monkey complete cord transection at first lumbar segment caused "spinal shock" or depression lasting several days. Some sort of plantar flexion was the first reflex to return, but nothing resembling a Babinski reflex occurred. Lateral cord semisection at the first lumbar segment caused a well marked Babinski response to strong stimulation on the sixteenth day.

Ablation of a part or a complete removal of an entire hemisphere caused a poor Babinski or none at all, respectively. This suggests that the pyramidal system is less completely dominant than in the higher forms. In the baboon these same procedures caused a Babinski response. The gibbon showed even more evidence of cortical dominance, and, finally, in the chimpanzee, whose motor cortex is nearer that of man than is that of any other infrahuman primate except the gorilla, the above procedures caused more profound reactions than in the lower orders.

A chapter is then given to a general discussion of the evolution of cortical dominance in man, and in the appendices the experimental methods involving the use of barbituric derivatives for anaesthesia and electrosurgical technique are described.

The studies represent a new approach to a large and most important subject, and the development of the plan should yield valuable results.

The Journal wishes to acknowledge the receipt of the following publications sent to the Editorial Department:

Norsk Magasin for Laegevidenskapen. Oslo, Norway, Vol. XCIII, Nos. 7, 8, and 9, July, August, and September 1932.

Slovanský Sborník Ortopedický. Brno, Czechoslovakia, Vol. VII, Nos. 2, 3, and 4, 1932.

Revista de la Facultad de Medicina. Bogotá, Colombia, Vol. I, Nos. 1, 2, and 3, June, July, and August 1932.

The Southern Surgeon. Vol. I, No. 2, July 1932.

United Fruit Company, Medical Department, Twentieth Annual Report, 1931. Boston, 1932.

Bulletin of the National Tuberculosis Association. Vol. XVIII, Nos. 8 and 9, August and September 1932.

The Journal of the Indian Medical Association. Calcutta, Vol. I, Nos. 8, 9, and 10, April, May, and June 1932.

Journal de Médecine de Bordeaux et du Sud-Ouest. Bordeaux, Vol. CIX, No. 13, May 10, 1932.

Life and Death in the Medical Profession. By Frederick L. Hoffman, LL.D. Newark, Prudential Press, 1932.

Announcements, The University of Chicago, The Medical Schools Number. Chicago, The University of Chicago Press, Vol. XXXII, No. 21, 1932.

Hyperparathyroidism and Osteitis Fibrosa Generalisata. John Hellström. *Acta Chir. Scandinavica,* LXIX, 237, 1932.

A critical survey of the literature of hyperparathyroidism, with tabulation of thirty-five cases in which parathyroids had been removed, strengthens the opinion that hyperfunction of these glands is one of the causes of osteitis fibrosa generalisata. In thirty-three cases actual enlargement of one or more glands was found. The results with parathyroidectomy were better, on the whole, than with other methods of treatment. In view of the occurrence of spontaneous remissions, the cases which had been under observation for only a short time were not accepted as permanently improved.

Three personal cases are reported in detail. In one an adenoma was removed with complete relief of symptoms. In the second there was temporary relief from the extirpation of an adenoma the size of a walnut; recurrent symptoms were entirely relieved by the removal of a second adenoma the same size as the first. In a third case with coincident hyperthyroidism, deep x-ray therapy resulted in remarkable general improvement and healing of the bones, although the serum calcium remained high. Reproductions of x-rays of the three cases before and after treatment are included.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

Osteochondritis Dissecans Capituli Radii. *Aage Nielsen. Acta Chir. Scandinavica,* LXIX, 305, 1932.

Osteochondritis dissecans of the right radial head is reported in three men, sixteen to twenty-two years old. Trauma was not a factor, and by none of the cases was the etiology clarified. With the forearm supinated the lesion was uniformly of the portion next to the ulna. Pain, weakness, limitation of motion, and atrophy were the chief symptoms. The loose pieces removed at operation were exactly similar to the ones removed in cases of osteochondritis of the humeral or femoral condyles.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

Multiple Myeloma of Bone: Report of Two Cases with Remarks on Histogenesis. Harold W. Williams. *Am. J. Cancer,* XVI, 540, 1932.

The author reported two cases of multiple myeloma with numerous photomicrographs. He suggested that the bone resorption, inevitably present, may be a key to the histogenesis of this tumor.

After reviewing current theories as to the origin of the tumor he presented evidence for the belief that the osteoblast is the cell of origin.—*Grantley W. Taylor, M.D., Boston, Mass.*

Chordoma Dorsalis of the Cervical Spine. Clarence I. Owen, Lynn N. Hershey, and Elisha S. Gurdjian. *Am. J. Cancer,* XVI, 830, July 1932.

The authors describe with photomicrographs and roentgenograms one case of chordoma of the cervical spine. They present also brief summaries of eight other cases which they were able to collect from the literature. On the basis of x-ray examination, the diagnosis has usually been tuberculosis of the cervical spine, although in their own case metastatic carcinoma was suspected. The symptomatology occasionally involves tenderness in the cervical spine, and frequently neurological symptoms, and paralyses. They suggested that in case of tuberculosis of the spine in which operation is performed, a biopsy should be done. The tumors are apparently not susceptible to radiation therapy.—*Grantley W. Taylor, M.D., Boston, Mass.*

Abnormalities of the Vertebral Body. William A. Evans. *Am. J. Roentgenol.,* XXVII, 801, June 1932.

This extremely timely and very excellent paper first takes up the normal variations peculiar to certain ages; these normal changes often lead to mistaken diagnosis

when they are not properly appreciated. Developmental anomalies are next discussed. Changes associated with nutritional disorders and disturbances of the endocrine glands are mentioned, and the importance of the early recognition of these conditions, the treatment of which may prevent scoliosis, is stressed.

Inflammatory changes—tuberculosis, syphilis, osteomyelitis, epiphysitis, osteochronditis and osteo-arthritis—are carefully differentiated. The spinal changes due to posture or occupation, and deformities secondary to intervertebral disc changes are discussed. Lastly, the spinal changes incident to constitutional disease and malignancy are given.

This paper is beautifully illustrated and is one of the best contributions that has appeared for some time.—*Edward S. Hatch, M.D., New Orleans, Louisiana.*

THE ROENTGEN SIGNS OF TUBERCULOSIS OF THE VERTEBRAL BODY. Howard P. Doub and Carl E. Badgley. *Am. J. Roentgenol.*, XXVII, 827, June 1932.

This paper correlates the characteristic roentgen pathology seen in the early spinal tuberculous lesions. Infection is by the hematogenous route. The question of cases originating primarily in the disc and by the lymphatic system are spoken of. Three types were found,—central and intervertebral articular and anterior.

The authors feel that spinal tuberculosis is devoid of symptoms until there is a collapse of the body and some involvement of the disc. Narrowing of the disc is the earliest and most constant roentgen sign in tuberculosis of the spine.—*Edward S. Hatch, M.D., New Orleans, Louisiana.*

DIE TIEFE SUBTROCHANTERE OSTEOTOMIE NACH SCHANZ BEI VERALTETER LUXATIO COXAE CONGENITA. (The Low Subtrochanteric Osteotomy of Schanz in Old Cases of Congenital Dislocation of the Hip.) Dahs und Schwarz. *Arch. f. Klin. Chir.*, CLXIX, 494, 1932.

Following a discussion of various methods of treatment employed in old cases of congenital dislocation of the hip, the authors made an analysis of forty-three patients in whom an end-result study was possible. Of these seventeen were unilateral, and twenty-six were bilateral dislocations. The Lorenz bifurcation operation was used in eight cases and the subtrochanteric osteotomy of Schanz in thirty-five cases. The latter method of treatment is preferred to any other form of palliative treatment. The analysis of their cases, both successes and failures, is very complete and instructive. The article contains reports of six typical cases.—*R. J. Dittrich, M.D., Fort Scott, Kansas.*

UNTERSUCHUNGEN ÜBER DIE VERÄNDERUNGEN AN DER GELENKKAPSEL UND IHRE BEZIEHUNGEN ZU DEN ERGÜSSEN DES KNIEGELENKS. (A Study of the Changes in the Joint Capsule and their Relations to Effusions of the Knee Joint.) Heinz Baumecker. *Arch. f. Klin. Chir.*, CLXX, 511, 1932.

From a study of the literature and his own investigations on the knee joint of man and animals, the author discusses the anatomy of this joint with reference to the physiological exchange of fluids. By the injection of dyestuffs and chemical methods, it was shown that an open communication between the joint cavity and the joint capsule does not exist.

By injection of sodium iodid into the knee joint, the process of absorption was studied. Sodium iodid, injected into the joint, could be demonstrated in the saliva of dogs in twenty-one minutes, and in the saliva of rabbits after fifteen minutes. Direct penetration through the isolated joint capsule was demonstrated by the injection of salicylic acid. In this a color reaction with iron chlorid was observed after six minutes.

With movement of the joint, the penetration of fluids through the capsule was hastened. Absorption was most rapid in the "zone of insertion".

On the basis of animal experiments and observations and investigations on the human knee joint, the important factors in traumatic effusions are considered. The microscopic changes of the synovia in traumatic injuries received special attention.

The degree of admixture of blood in traumatic effusion was dependent on the extent and the location of the injury to the synovia.

Investigations of the influence of nerves on the joint fluid led to a positive result only in case of periarterial sympathectomy. Following this operation, a vasodilatation was noted in the joint capsule and the absorption from the knee joint was hastened. An increased absorption could not be demonstrated after fourteen days.

The cause of recurrent effusion was traced back to changes in the synovial membrane.

Investigations of the healing of joint wounds showed that an interruption of continuity in the synovial membrane heals by formation of fibrous tissue. Regeneration in uncomplicated wounds was completed in two to three weeks. Joint wounds sutured with silk or catgut healed more slowly and showed a more intense inflammatory reaction. The inflammatory changes in silk sutures were less severe than in those of catgut.

It was shown experimentally that the synovial membrane, in case of para-articular inflammation, acts temporarily as a protection to the joint cavity. Absorption is more rapid from inflamed joints.

Ligation of the femoral vein was followed by effusion and hemorrhages of the synovia. Absorption was increased. The same changes were produced by immobilizing the thigh with a plaster cast.—*R. J. Dittrich, M.D., Fort Scott, Kansas.*

Die Körperhaltung bei Einseitiger Beinbelastung und ihre Änderung bei Ausfall der Hüftabductionsmuskeln. (Body Posture When Standing on One Leg and its Variation in Paralysis of the Hip Abductors.) H. Storck. *Arch. f. Orthop. u. Unfall-Chir.*, XXX, 299, 1931.

This paper is based on the observation of Gocht that patients with unilateral hip dislocation can improve their gait decidedly by carrying a weight in the hand of the affected side. Storck made similar observations on patients with unilateral paralysis of the hip abductors and explained the phenomenon by the construction of simple mechanical models. A patient who ordinarily would have to tilt the body twenty-five degrees to the left to maintain balance, when standing on the left leg, can hold the body almost erect when the left hand carries a weight of twenty kilograms.—*Leo Mayer, M.D., New York, N. Y.*

Die Angeborene Gibbusbildung mit Wirbelkörperspaltung an der Unteren Brustwirbelsäule. (Congenital Gibbus Formation with Cleft of the Body of Vertebra of the Lower Dorsal Region.) Walther Müller. *Arch. f. Orthop. u. Unfall-Chir.*, XXX, 319, 1931.

Five cases of this type of congenital deformity are cited, in which the diagnosis might have been confused with Pott's disease or fracture of the vertebra, were it not for the peculiar cleft of the body of the vertebra visible in the anteroposterior x-ray view, giving a butterfly-shape to the x-ray shadow. Müller emphasizes as an important characteristic of this deformity its location in the lower dorsal region, approximately in the middle of the primitive embryonic spinal segments. He believes that this location helps to explain the development of the deformity by a flexion of the primitive spine, coupled with some developmental anomaly of the vertebrae.—*Leo Mayer, M.D., New York, N. Y.*

INDIREKTER HALSWIRBELSÄULENBRUCH. (Indirect Fracture of a Cervical Vertebra.) Ludwig Strauss. *Arch. f. Orthop. u. Unfall-Chir.*, XXX, 331, 1931.

The author describes an unusual tear fracture of a small portion of the anterior border of the fifth cervical vertebra. The patient, a muscular man of thirty-two, following a vigorous swim, noted a sudden pain in the neck and right shoulder and inability to hold the head straight. The symptoms, however, were not severe enough to necessitate stopping work until five days later when, after swimming again, the pain became extreme, the patient noted marked weakness of the right arm and extreme pain at any attempt to move the head or arm. The lateral x-ray showed a tear fracture of the lower anterior margin of the body of the fifth lumbar. The fragment was about the size of a pea. The patient made an uneventful recovery after primary immobilization followed by physiotherapy.—*Leo Mayer, M.D., New York, N. Y.*

KLINIK UND PATHOLOGIE DES MALUM PERFORANS MIT BESONDERER BERÜCKSICHTIGUNG DER SKELETVERÄNDERUNGEN. (Clinical and Pathological Aspects of Malum Perforans with Particular Considerations of Skeletal Changes.) Oscar Scaglietti. *Arch. f. Orthop. u. Unfall-Chir.*, XXX, 392, 1931.

Three cases are described; in one amputation was performed, the other two patients died and were autopsied. One of the latter had tabes; the other two had no lesion of the central nervous system. The skeletal changes were followed in a series of roentgenograms and the final condition studied microscopically. Even before the ulcer had penetrated to the joint and thus infected it, the joint showed superficial necrosis of the cartilage and pannus formation. Following the infection of the metatarsophalangeal joint, extensive bony necrosis occurred, producing complete destruction of the joint and sequestration of the metatarsal bones and phalanges. This accounts for the characteristic shortening of the foot and the dorsiflexed position of the toes. A striking fact is that, after almost complete disappearance of a metatarsal bone, it can be almost completely regenerated. The microscopic changes incident to this regeneration could be traced in a large series of sections.

The paper though thorough, does not throw any additional light on the cause of malum perforans.—*Leo Mayer, M.D., New York, N. Y.*

VERSUCHE ÜBER RASCHE UND BLEIBENDE AUSFÜLLUNG VON OBERFLÄCHENDEFKTEN AN DEN FREIEN KNORPELKNOCHENENDEN DER GELENKE. (Experiments Dealing with Rapid, Permanent Filling of Superficial Defects of the Joint Cartilage.) Wilhelm Ammenwerth. *Arch. f. Orthop. u. Unfall-Chir.*, XXX, 435, 1931.

The knees of twenty dogs were operated on. A small bit of cartilage was removed with a gouge, exposing the bone. The defect was filled with a bit of muscle which was simply pressed into place. Although no fixation sutures of any kind were used and the animals were allowed immediate use of their limbs, in every case at autopsy the transplant was found *in situ*. In only a few of the earlier experiments was there any excess of joint fluid. In none were there arthritic changes. Microscopically the muscle showed a primary necrosis and gradual replacement with connective tissue. The cells on the surface assumed a parallel arrangement and gradually the spindle shape changed to a round form, resembling cartilage. Finally the tissue closely resembled fibrous cartilage.—*Leo Mayer, M.D., New York, N. Y.*

UNTERSUCHUNGEN ÜBER DIE HEREDITÄT ORTHOPÄDISCHER LEIDEN. III. DER ANGEBORENE SCHIEFHALS. (Researches Dealing with the Heredity of Orthopaedic Anomalies. III. Congenital Torticollis.) Eduard Isigkeit. *Arch. f. Orthop. u. Unfall-Chir.*, XXX, 459, 1931.

This article is a statistical survey of 2673 cases. The heredity factor could be proven in eleven per cent. The author rejects the traumatic theory of Strohmeyer

and the intra-uterine pressure theory of Petersen. He concludes that congenital torticollis is an hereditary anomaly, recessive in type,—probably of the dihybrid variety. It is influenced to a certain extent by external factors. Its pathology is and aplasia of the sternocleidomastoid, due to insufficient differentiation of the muscle tissue from the primitive mesenchyme. It is not the result of an abnormal intra-uterine position, but is rather the cause of such abnormal positions. In twins heredity could be demonstrated in twenty per cent. of the cases. The sexes were affected equally. Breach presentations and transverse positions occurred in fifty per cent.; difficult labor in seventy per cent. of the cases. The condition occurs more frequently in the first-born.—*Leo Mayer, M.D., New York, N. Y.*

Isolated Fracture of the Carpal Semilunar and Kienböck's Disease. T. B. Mouat, John Wilkie, and H. E. Harding. *British J. Surg.*, XIX, 577, April 1932.

Fracture of the carpal semilunar is not uncommon, though often unrecognized. The process of repair in the damaged bone is retarded by the defective blood supply and the poor reactive powers of its cartilaginous covering.

A slow progressive degeneration—"Kienböck's disease"—with absorption of necrotic bone lamellae and fibrous replacement, then takes place during a varying and often long quiescent interval, which is ultimately followed by deformation of the bone, with recurrence of the local symptoms and continued disability.

A similar local reaction may result from repeated minimal occupational traumata and in exceptional cases may be caused by an attenuated infection.

A Case of Parathyroid Tumour Associated with Fibrocystic Disease. G. Gordon-Taylor and Philip Wiles. With a Pathological Account by S. L. Baker. *British J. Surg.*, XIX, 606, April 1932.

A girl of twenty sustained a spontaneous fracture of the left femur due to localized cystic disease. Five months later the leg was amputated because of non-union. The parathyroid syndrome had not been recognized at this time. Two months later x-rays of all the long bones showed marked pathological changes. Three months later she sustained a fracture of the right femur. Exploration of the parathyroids revealed a definite tumor on one side and this was removed. Union then took place in the femur and the other bones became more normal.

A careful description is given of the parathyroid tumor and the bone tumors and also the results of careful blood chemistry at various stages of the disease.

Chronic Polyarthritis—Its Group Treatment. Rea Smith. *California and Western Med.*, XXXVI, 145, 1932.

The author starts with the premise that chronic polyarthritis is of intestinal origin either of bacterial toxins or metabolic products, and, after clearing up the other sources of infection, such as the teeth, tonsils, sinuses and pelvis, bases his main hope on elimination of toxins and bacteria from the bowel source. He proceeds to restore the normal flora of the bowel by an abdominal belt and sleeping with the pelvis raised and colonic irrigations and the implantation of acidophilus bacillus and diet. The purpose is to change the flora to a normal relationship between the gram.-negative and gram.-positive bacteria. Gastro-intestinal x-rays are taken and special notice is made of the motility of the caecum. In case of an immobile caecum, then operative mobilization must be done, else the intestinal flora will return to its old imbalance.

The operative work is based on the conception that the descent and fusion of the ceacum causes pinching of Auerbach's plexus, and that the caecum dialates and becomes thin, pale, and apparently atrophic. The technique is described in detail. The author finds no other method to be of value for this purpose by reason of the primary cause being the pinching of the nervous plexus; and plicating the caecum would defeat its

object because it would give no relief to the plexus. Any kind of mechanical fixation of any part of the caecum prevents the contraction of the longitudinal bands. The author has never had to re-operate for recurrence of the membrane in a series of about three hundred cases extending over a period of twelve years.—*Charles Lyle Hawk, M.D., Los Angeles, California.*

SEMILUNAR CARTILAGES—THEIR REMOVAL FROM THE KNEE JOINT. George J. McChesney. *California and Western Med.*, XXXVII, 98, 1932.

The author reports on twenty-seven cases referred to him by various insurance companies. The average age was forty-one years; the average time from injury to operation was five months, and from operation to examination by the author seven months. There was crepitation in all cases, and locking in thirty-seven per cent.; tenderness was frequent. Complete extension could be obtained, though the quadriceps was usually atrophied. The x-ray showed arthritis in fifty per cent.

He also investigated the records of the California Industrial Commission for 1930 and found over half of the cases to have been rated more than ten per cent. disability. He quotes D'Arcy Power's report in the *British Medical Journal* (I, 61, 1911) on eighty-nine cases in which seventy-three had no return of symptoms; sixteen experienced recurrences; fifty reported normal strength, while thirty-nine complained of weakness.

He believes that the reasons for such a high disability rating in this country were lack of cooperation by the patient or his desire to obtain a higher rating, the climatic conditions, the nature of the work to which the patient returned or—what was more important—the age of forty-one. He also believes that many cases are improperly diagnosed and that operation is often unnecessary.—*Charles Lyle Hawk, M.D., Los Angeles, California.*

THE TREATMENT OF FRACTURES, BY MEANS OF SKELETAL DEVICES. H. W. Orr, *J. Am. Med. Assn.*, XCVIII, 947, 1932.

Because the modern demand in the treatment of fractures is for correct anatomical replacement of injured parts and recovery with a maximum of function, and because of the low percentage of first class results from the use of weight and pulley or elastic traction, and the inefficient methods of fixed traction in splints, technique must be improved in the primary reduction and the control of the fracture and patient during the period of healing. The use of skeletal traction devices and the incorporation of these fixation devices in a plaster-of-Paris cast has given better control of the fracture than any other splint.—*Ruth Jackson, M.D., Dallas, Texas.*

ARTHRITIS OF THE CERVICAL SPINE. Some Neurologic Manifestations. J. Dewey Bisgard. *J. Am. Med. Assn.*, XCVIII, 1961, 1932.

Recent investigations have shown that radiculitis of arthritic origin is a common manifestation of vertebral arthritis, and in magnitude these radicular symptoms far exceed symptoms referable to the local arthritic process, thus producing many variable and bizarre symptom complexes which receive many different diagnoses. Not only is this radiculitis manifest in the symptoms, but also it is frequently betrayed by sensory and motor changes in the involved areas.

Symptoms of sixty cases of arthritis of the cervical spine are analyzed and ten illustrative case histories emphasize the remoteness of local symptoms of arthritis as compared to the symptoms, sensory and motor findings which predominate and which are due to radiculitis from the arthritic process.

History of cases in which there was complaint of occipital and suboccipital headaches could be explained by radiculitis of the cervical spine. Thirty-eight had pain, tenderness, stiffness, and crepitation, localized in the neck; eight had "neuritis" in the shoulders and arms; five noted marked sensory disturbances in hands and arms, and four showed definite motor nerve involvement, all as a result of involvement of

the nerve radicles by the lipping and osteophytic outgrowths of chronic vertebral arthritis.—*W. B. Carrell, M.D., Dallas, Texas.*

Non-Tuberculous Arthritis. A Descriptive Classification. M. J. Shapiro. *J. Am. Med. Assn.*, XCVIII, 1965, 1932.

The author refers to the original work of Nichols and Richardson who found only two groups into which arthritis would invariably fall,—namely, the proliferative and the degenerative types. These groups do not necessarily differ in etiology since one group sometimes merges into the other and of two persons having identical clinical manifestations one may show the degenerative and the other the proliferative type of pathology.

A recent review of the literature by the author finds that the workers in this field are using several different classifications of arthritis, and he shows how many of these classifications are not scientifically sound, as some are based on etiology and some on roentgenographic appearance. Since the etiology of many arthritides is still unknown, roentgenographic views of the same process may vary from time to time.

The classification proposed by the American Committee is too stiff and unflexible, and cannot be followed in classifying every case of arthritis; hence, the author presents a new classification which, although it is somewhat cumbersome, is nevertheless entirely adequate to classify any case of arthritis, since it is based on descriptive terms pertaining to arthritis, the meanings of which are unmistakable. This classification takes into consideration in the naming of a particular case of arthritis, its clinical aspect, etiological, pathological, anatomical, and roentgenographic aspects and whether it is monarticular or polyarticular.—*W. B. Carrell, M.D., Dallas, Texas.*

The Orthopedic Treatment of Infantile Paralysis. Charles Leroy Lowman. *Northwest Med.*, XXXI, 136, 1932.

The author states that the orthopaedic treatment of infantile paralysis should begin simultaneously with the medical treatment, and that deformity need not exist in more than one per cent. of the cases. Mixed polyvalent convalescent serum is now used and evidently is an aid as a therapeutic agent. In case serum cannot be obtained, whole blood from a recovered case may be transfused into the abdominal muscles. Physiological rest should be maintained; too early massage and manipulation will often produce more crippling. The pain in the muscles may tempt the mother to raise the knees on a pillow, thus contributing towards deformity. She may at times allow the bed clothes to stretch the paralyzed tibialis anticus and produce more foot drop. Good bed posture contributes towards less paralysis and no deforming contractures. The acute muscle soreness and neuritis are relieved by casts and plasters half-splints. Deformity is a secondary condition, especially if postural faults exist prior to the disease. Parents must be taught the nature of the disease and the why and wherefore of the treatment, as it may save unnecessary disability and loss of time through neglected cases. The physiological splinting treatment should continue for six or seven weeks, then reeducational exercises should be started without pain or fatigue, the weight being carried by an assistant.

The warm pool is a valuable addition to muscle reeducation, and is begun just after quarantine or at the end of the fourth week, if there is no kidney contra-indication. The physiological demand for nutrition of muscles is in direct ratio to the activation and hence they are nourished and no atrophy occurs. The purpose of muscle training is the reopening of the neural channels from the brain and this is more rapidly arrived at by the more free underwater exercises, where the reflex arcs and neural patterns are formed by reason of the sense of motion. The dosage must not reach fatigue.

Operative reconstruction is considered. In old cases the deformity is first corrected, then reeducation is begun.

The child's social and educational outlook should be given consideration to enable him to meet the new conditions.—*Charles Lyle Hawk, M.D., Los Angeles, California.*

CHRONIC ATROPHIC ARTHRITIS: ITS MODERN CONCEPTIONS. Edward A. Rich. *Northwest Med.*, XXXI, 327, July, 1932.

The author believes that atrophic arthritis is a constitutional disorder resulting in vascular deficiencies, and not caused by local infection. He considers it a vasomotor constriction disease which produces a vicious cycle when the arthritic structures become atonic. The patients belong to a class complaining of inanition and chronic fatigue and are often diagnosed as "run down", "overworked", or "anaemic". The patients are scant eaters and dislike fats. The prodromal stage is characterized by asthenia and avascularity. The fingers become numb and spindle-shaped. There is a history of sudden joint involvement following some debilitating disease. The terminal stage presents soreness and stiffness of the joints followed by absorption and ankylosis.

It is only cured in the preliminary stage when the underlying vascular deficiencies can be successfully treated. The medical profession should be ever alert to on-coming arthritis in asthenic cases. The author believes that the recovery of streptococcus from the periarticular structures means no more than their recovery from any other anatomical area.—*Charles Lyle Hawk, M.D., Los Angeles, California.*

ANOMALIES OF THE LOWER SPINE: CONSEQUENCES AND TREATMENT. R. R. Vreden. *Orthopaedia i Travmatologia*, V, No. 4, p. 5, 1931.

A modified Putti classification of the anomalies of the lumbosacral spine is proposed. They are divided into four groups:

Anomalies of differentiation of the vertebrae,
Anomalies concerning the number of the vertebrae,
Anomalies affecting the form of the body and parts of the vertebrae,
Various and simultaneous combination of the previous anomalies.

A detailed analysis of the symptoms observed in each group is given. The method of treatment is dictated by several factors: age, social status, etiology, and degree of deformity. At an early age conservative treatment is indicated. Between eight and fifteen years an osteoplastic fusion in the corrected position is advised. The only radical procedure is a stable immobilization of the lower lumbar vertebrae and the sacrum by means of fusion. In rare cases of spina bifida sacralis, a resection of the spinous process of the fifth lumbar is added. A series of 104 patients have been operated upon. Henle's, Whitman's, Halstead's, and the author's methods of operation were used. The results were gratifying, although in several cases consecutive physiotherapy was necessary. In five per cent. of the operated cases, intestinal manifestations, simulating obstruction, were observed which were probably due to thrombosis of the mesenteric veins widely anastomosing with the pelvic veins. There was no mortality in this series.—*Emanuel Kaplan, M.D., New York, N. Y.*

HABITUAL DISLOCATION OF THE HUMERUS. B. K. Babitch. *Orthopaedia i Travmatologia*, V, No. 4, p. 29, 1931.

The author reviews the anatomy, etiology, pathology, and mechanism of this affliction. Twenty-five patients were under observation. The operative treatment is considered the best, although there are numerous procedures,—Oudard found 150 different methods of operation.

Eleven patients were operated upon at the Ukrainian Institute of Orthopaedic Surgery and Traumatology; postoperative duration three and one-half years to six months, results very satisfactory. Seidel's technique modified by Sitenco was used. A longitudinal incision, ten to twelve centimeters long, is made over the anterolateral aspect of the shoulder, exposing the capsule through the deltoid, followed by external rotation of the arm and division of the tendon of the subscapularis at the lesser tuberosity of

the humerus. A strip of fascia lata, seventeen centimeters by three centimeters, is then inserted at the medio-inferior angle of the joint capsule and, after internal rotation of the arm, is drawn across in front of the joint upward and externally. The fascial strip is then passed under the deltoid and attached to the acromion. An abduction splint is applied and motion and massage started on the tenth day; the splint is removed on the fifteenth day.—*Emanuel Kaplan, M.D., New York, N. Y.*

UNDESCENDED SCAPULA WITH AN OMOVERTEBRAL BONE. Byron H. Jackson. *Radiology,* XIX, 67, 1932.

This article is a study of a case of undescended scapula, with an omovertebral bone connecting the upper half of the vertebral border of the left scapula to the cervical spine.

The patient suffers no restriction of activity from his deformity except inability to elevate the arm above the horizontal plane, being able to engage in athletic sports and to function as a coal miner. He is well developed and healthy. His whole left chest and shoulder girdle are higher than his right. The left shoulder and clavicle are thrown forward about one inch in front of his right and the lower half of his neck is much wider than the right. The lower angle of the left scapula is three and one-half inches higher than the right. The superior border bends sharply forward. There is a dorsal scoliosis, with convexity to the right. Occupying the usual position of the normal superior vertebral angle is an oblique border three and three-quarters inches long, to which is attached, by cartilage, a triangular bridge of bone five inches long, its apex extending upward to a firm attachment to the third or fourth cervical spine.

The terms "Sprengel's Deformity" and "Congenital Elevation of the Scapula" are objectionable for this condition, which is actually due to failure of descent of the scapula and should be known as "Undescended Scapula".

"The arm of the human embryo is cervical in position. It descends during the second month."

Undescended scapula is always accompanied by other defects or anomalies,—*viz:*

Defects of the cervical spine with or without an omovertebral bone.

Defects of muscles with or without bony defects.

An omovertebral bone, without defects of the cervical spine.

These represent the three forms of the condition.

The forward bending of the supraspinous portion of the scapula is common to all types of undescended scapula, due to the molding of muscles on the bone retained in its original embryonic position.

The common characteristics of omovertebral bones, as reported in the literature, are:

They are attached to the scapula by cartilage, just as rib is attached to the sternum.

They have articular facets by which they are attached to the cervical spine.

They are provided with tubercles.

In composition they resemble ribs.

The author believes that omovertebral bones represent cervical ribs, arising from vertebrae above the seventh cervical and attaching by their costal cartilage to the scapula, with which they come in contact during the first few months of intra-uterine life.—*Edward N. Reed, M.D., Santa Monica, California.*

SUR UN NOUVEAU PROCÉDÉ D'ARTHRODÈSE-RÉSECTION DE LA HANCHE ET D'OSTÉOTOMIE DANS LES COXALGIES ANCIENNES ET ARTHRITES DÉFORMANTES. Jacques Calvé. (Société Belge d'Orthopédie, November 1931.) *Scalpel,* LXXXV, 373, 1932.

Dr. Calvé describes a new technique for arthrodesis of the hip, worked out on the cadaver, and presented before the Belgian Orthopaedic Society. In brief, the method consists of opening the area of the hip joint through a lateral vertical incision, opening the capsule above, section of the trochanter by an inverted Y osteotomy, separating

the two fragments laterally, but preserving the aponeurotic attachments, section of the neck, removal of neck and head, with thorough cleaning of the diseased area. The limb is then put into the desired position and the two trochanter fragments put into place, making a live graft on either side between the diaphysis and the ilium.

FRACTURES OF THE SHAFT OF THE FEMUR. S. O. Black. *Southern Med. J.*, XXV, 739, July, 1932.

For children under sixteen years of age, skin traction is used; for adults, skeletal traction combined with Thomas splint and suspension. Ice tongs with the knee flexion on a Pearson flexion attachment is the method of choice. Traction for six to eight weeks, then protection in bed two or three weeks longer is necessary. Then a caliper splint should be applied and walking started. Plaster-of-Paris has been practically abandoned in the treatment of fractures of the femur. When traction fails, the Sherman technique of open operation and internal fixation with metal plates is used. Should non-union occur, a massive onlay autogenous bone graft is advised.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

FRACTURES OF THE PELVIS. G. W. Leadbetter. *Southern Med. J.*, XXV, 742, July, 1932.

The treatment of fracture of the pelvis by allowing the patient to rest in bed, and applying an adhesive strap or two, or an encircling belt is, in the large percentage of cases, no treatment at all. Accurate diagnosis by means of stereoroentgenographs is the first essential. Then the presence of any serious complications should be determined. An effort should be made to restore and preserve the continuity of the pelvic ring. Cases with definite dislocation of fragments are treated by suspension and traction. A Balkan frame, Thomas splints, and adhesive traction are first used. If these do not succeed in proper reduction, skeletal traction is used. Traction is kept up about six weeks; then rest in bed with a pelvic belt about two weeks. Walking is started about the tenth week. Open operation has been done in very few cases.—
Fred G. Hodgson, M.D., Atlanta, Georgia.

PRIMARY OSTEOMYELITIS (CHRONIC FIBROUS) OF THE ANTERIOR SUPERIOR SPINE OF THE ILIUM. Report of a Case. R. C. Robertson. *Southern Med. J.*, XXV, 825, Aug. 1932.

A boy thirteen years of age had pain and swelling, in region of the anterior superior spine. Slight rise in temperature. X-ray showed a small area of destruction in this region. Diagnosed as primary malignancy; four treatments of deep x-ray therapy were given. Pain and limp disappeared. Was free of symptoms for three months. Symptoms returned. Exploratory operation under ether: schlerotic areas with grayish soft tissue cleaned out. Cultures showed staphylococcus aureus. Microscopically fibrous tissue only was found. After two years patient is entirely well.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

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